Revised and Expanded

Energy83

$1.25

Energy83

A message from the Vice President of the United States.

Dear Students:

This is an important and exciting study for American students, for the very future of our country will depend upon the understanding, the development and conservation of energy resources.

Because America is so large and its resources so diverse, this study will also broaden understanding of our country. Some areas are blessed with abundant coal reserves — but will have to develop efficient methods of health safety and ways to transport the coal. Other areas exist largely on imported oil — thereby making the implications of international fuel supply vitally important. In sections that are rich in oil and natural gas, ways to reduce the costs of producing the energy must be developed.

For the longer term, research and development must continue in solar, geothermal and nuclear energy. I am confident that America has the intellectual and scientific skills to lead the world to cleaner and more efficient energy resources. Having started in the oil business 35 years ago, I know that each time a problem seemed impossible, a solution was found. I believe the next 35 years will see advances in other energy fields just as dramatic.

Planning and programs for effective control and protection of our energy and environmental needs begins with the choices and sacrifices we are each making daily. Whether it's turning off lights, riding bikes instead of cars or wearing sweaters indoors, conservation must become a way of life to us. We also need to recognize that many energy forms can produce environmental effects which must be taken into account, and develop a balance between environmental concerns and the legitimate demands of a vigorous, healthy economy.

Energy demands our immediate attention. New habits must be formed; fresh alternatives must be inaugurated. The harnasing of viable new energy sources must be researched. You, as students, are our most valuable resource in making all this happen. We are counting on you, and we know our trust will be honored.

Sincerely,

George Bush

George Bush
Vice President
of the United States

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This booklet is yours to take home and keep. When you are at home, answer these questions. As you learn more about energy, you'll find out how accurate your answers were. You don't have to show your answers to anyone.

This Energy Book belongs to: ____________________

How many gallons of gasoline would you guess
your family uses in a year? ____________________ gallons

How many dollars worth of electricity? ____________________ dollars

How many dollars worth of natural gas? ____________________ dollars

How many dollars worth of fuel oil? ____________________ dollars

If you can think of any other
kinds of energy you use, write
them here: ____________________

What single use consumes the most energy in your home? ____________________

Second biggest? ____________________

Does your family have a car? How many miles
per gallon does it get? ____________________ mpg

Do you have a hot water heater?
What temperature is its thermostat set at? ____________________ degrees F

Is your home heating controlled by a thermostat?
In the winter, what is its setting? ____________________ degrees F

Do you have air conditioning?
In the summer, what is its setting? ____________________ degrees F

Through what part of your home can heat
escape most easily? ____________________

Here are the five biggest sources of the energy used in the U.S. Answer each of the following questions by writing the number for one of the energy sources.

1. coal
2. hydroelectricity
3. natural gas
4. nuclear fission
5. oil

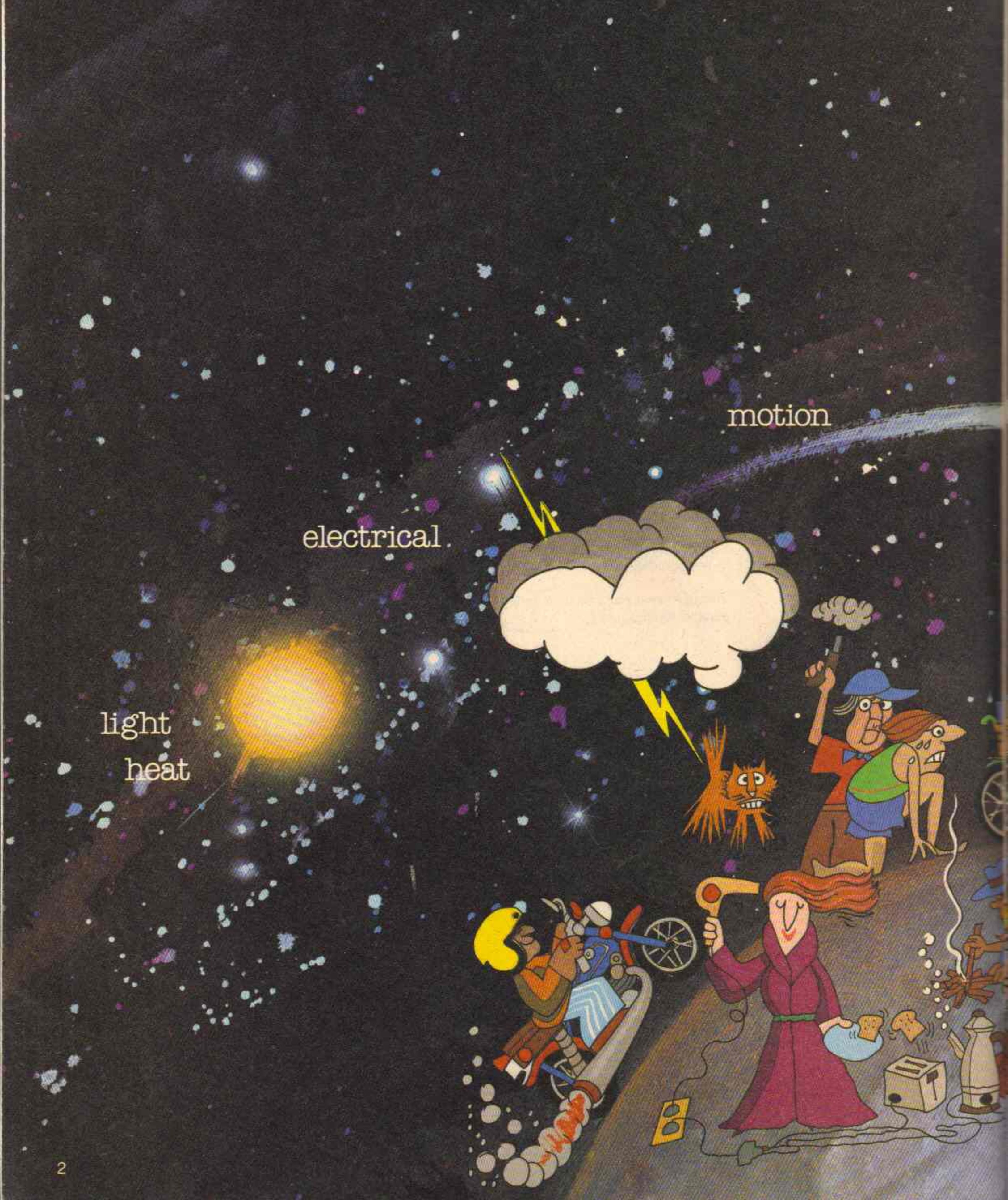
Which energy source provided the most energy last year? ________ Which energy source was most important in generating electricity? ________ Which energy source do we produce the most of in this country? ________ Which energy source provided most of our energy in 1940? ________ Almost half of the energy from one of the sources came from other countries. Which source? ________ Which energy source provides almost all the energy used to move people and things around the country? ________ Which energy sources came from sunlight? ________ Which energy source is most important in heating homes in the part of the country where you live? ________ Which energy sources were used to produce the electricity you use in your home? ____________________

On a separate piece of paper, answer these questions.

What would be the best thing your family could do to reduce your energy costs for transportation? What would be the best thing your family could do to reduce your energy costs for heating (and cooling) your home? If you were going to replace one appliance in your home with another that did the same job but used less energy, what would it be? Why? What do you think is the most important thing the country should do about energy?

Tuck the paper into this book and save it until your class finishes studying energy. Then see if your ideas have changed.

In all the universe there is only matter

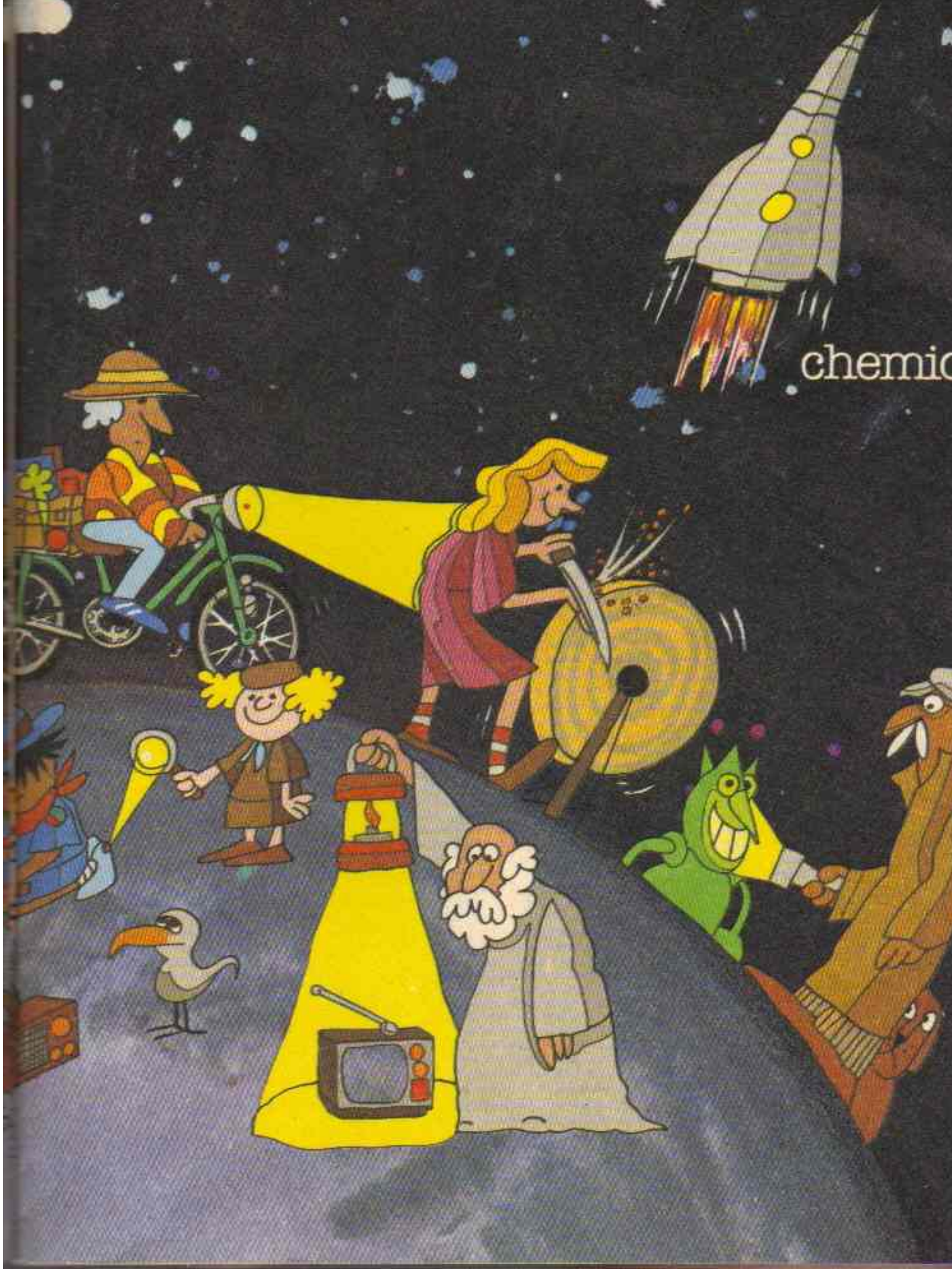


. . . and ENERGY

light energy,
heat energy,
chemical energy,
the energy of motion,
electrical energy

Many kinds of energy—but it's all energy. Energy changes from one form to another—but it can't be created or destroyed. (Under some very special conditions, matter can be changed into energy—for example in the sun or an atomic bomb.) Mostly, though, when energy seems to be made or to disappear, it is just changing from one form to another.

To use energy, people almost always have to change it from one form to another. Often we use machines to do this. A candle changes chemical energy to heat and light; an automobile changes chemical energy in gasoline to heat and the heat into motion. What kind of energy is each person in the drawing starting with, and what kind are they trying to get?



Energy... rules of the game

Whenever we change energy from one form to another, part of the energy becomes heat. When you turn on a fan to cool yourself on a hot day, you don't want heat. You want to change electrical energy to the motion of air. But what happens? The electric motor gets hot. Part of the electricity is changing to heat.

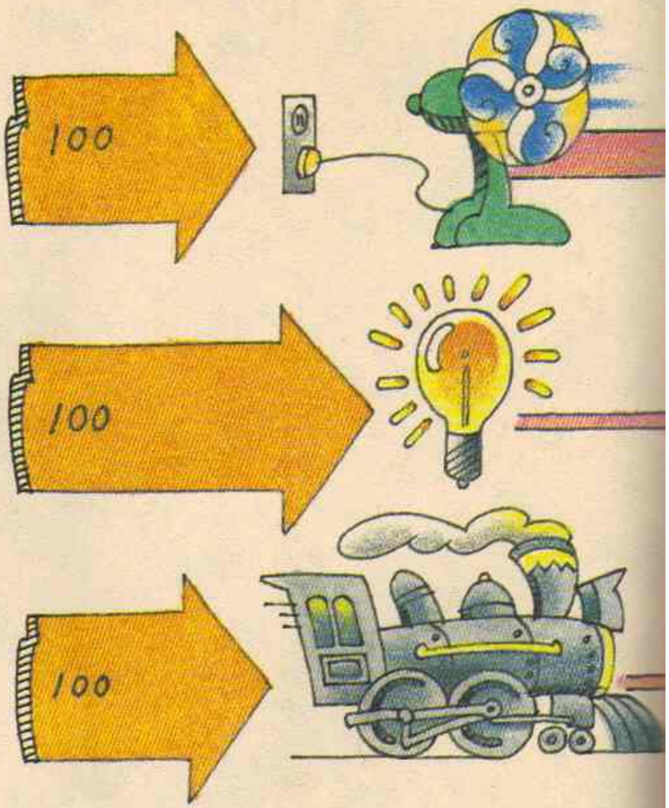
We want the chemical energy stored in gasoline to move the motorcycle. But a lot of the energy becomes heat in the exhaust or engine.

We want the light energy shining on a green leaf of corn to be stored as chemical energy in the plant. But most of it just warms the leaf. As time goes on, more and more of the energy in the universe gets changed to heat.

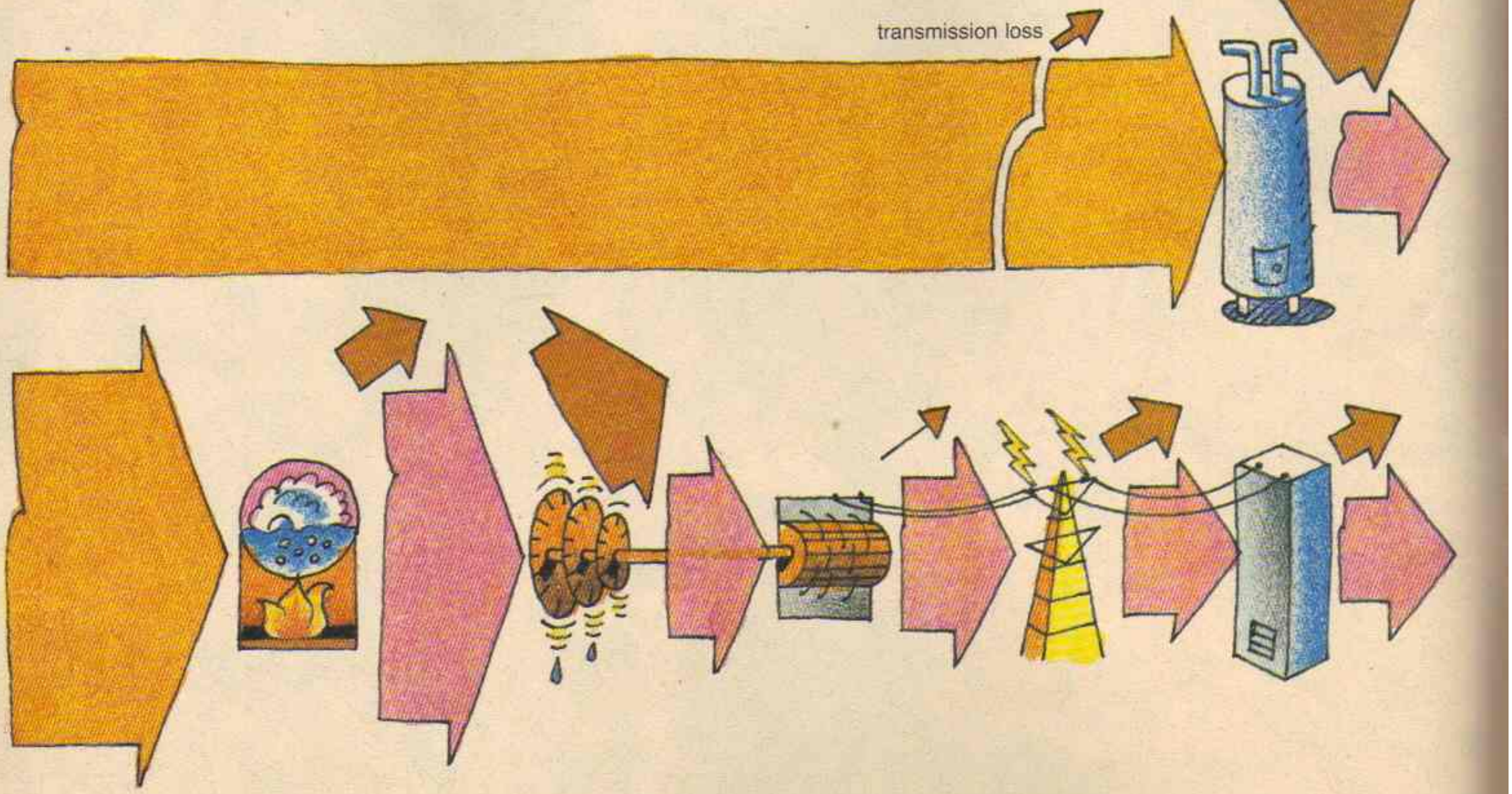
When we change energy from one form to another, only part of the energy we put in will come out in the form we want it. How much we can get is called efficiency. The efficiency of the fan motor is about 35%; of the motorcycle about 20%; of the leaf about 3%.

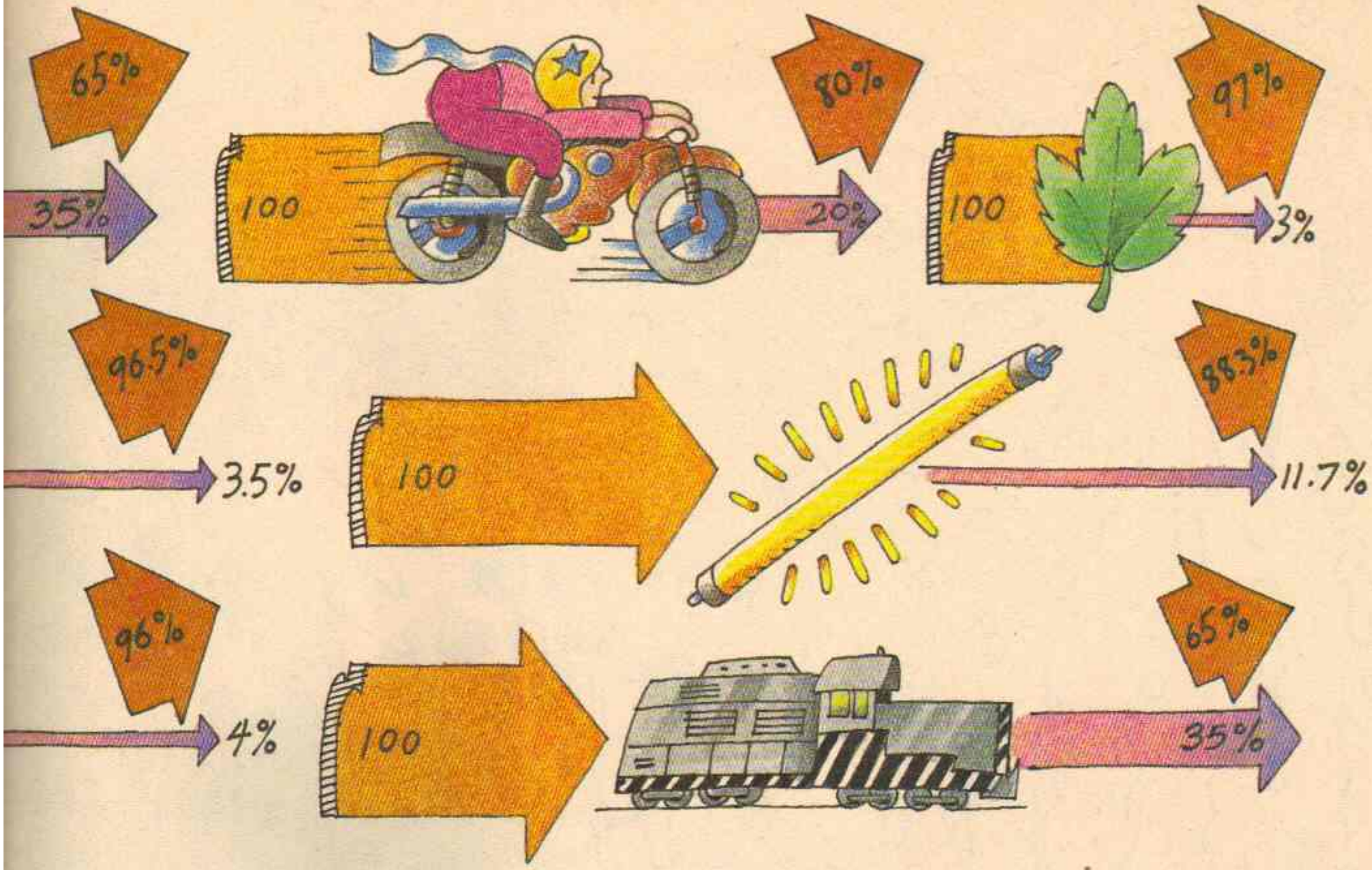
Inventors try to find more efficient ways of using energy. An incandescent bulb changes from 2.5% to 4.5% of the electrical energy it receives into visible light. 8.5% to 15% of the electricity entering a fluorescent lamp is changed to visible light.

Coal-burning steam locomotives had an efficiency as low as 4%. Modern diesel electrics have efficiencies of around 35%.



System Efficiency





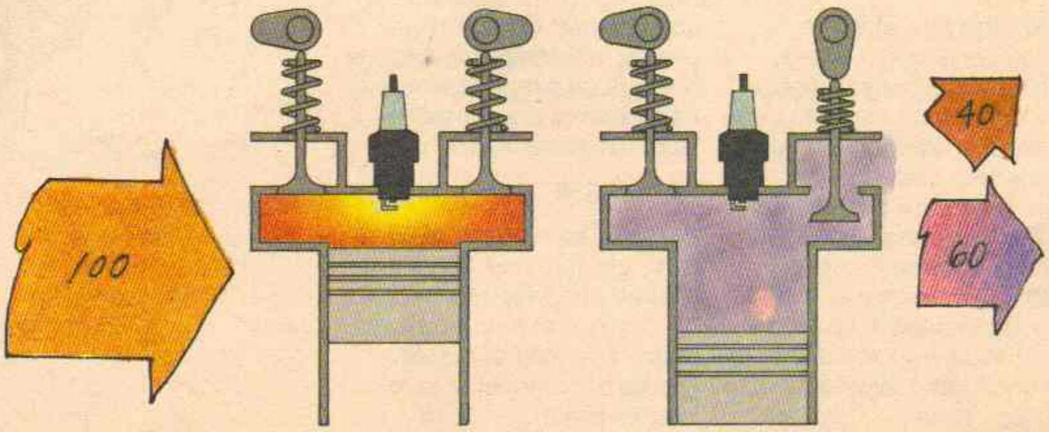
Energy flows. When you look at the efficiency of only part of an energy flow, you can get fooled. For example, an electric water heater has an efficiency of about 79% and a gas water heater about 46%. The electric heater looks better.

But suppose that electricity came from a power plant that burned gas (15% of the electricity used in the United States last year did). The efficiency of the *boiler* was probably around 88%; of the *turbine* 47%; of the *generator* 99%; and of the *wires* and other parts of the transmission system about 80%. The result is that the whole electrical system plus water heater has an efficiency of around 26%. Nearly twice the gas needed for the gas heater must be burned to heat water in the electric heater.

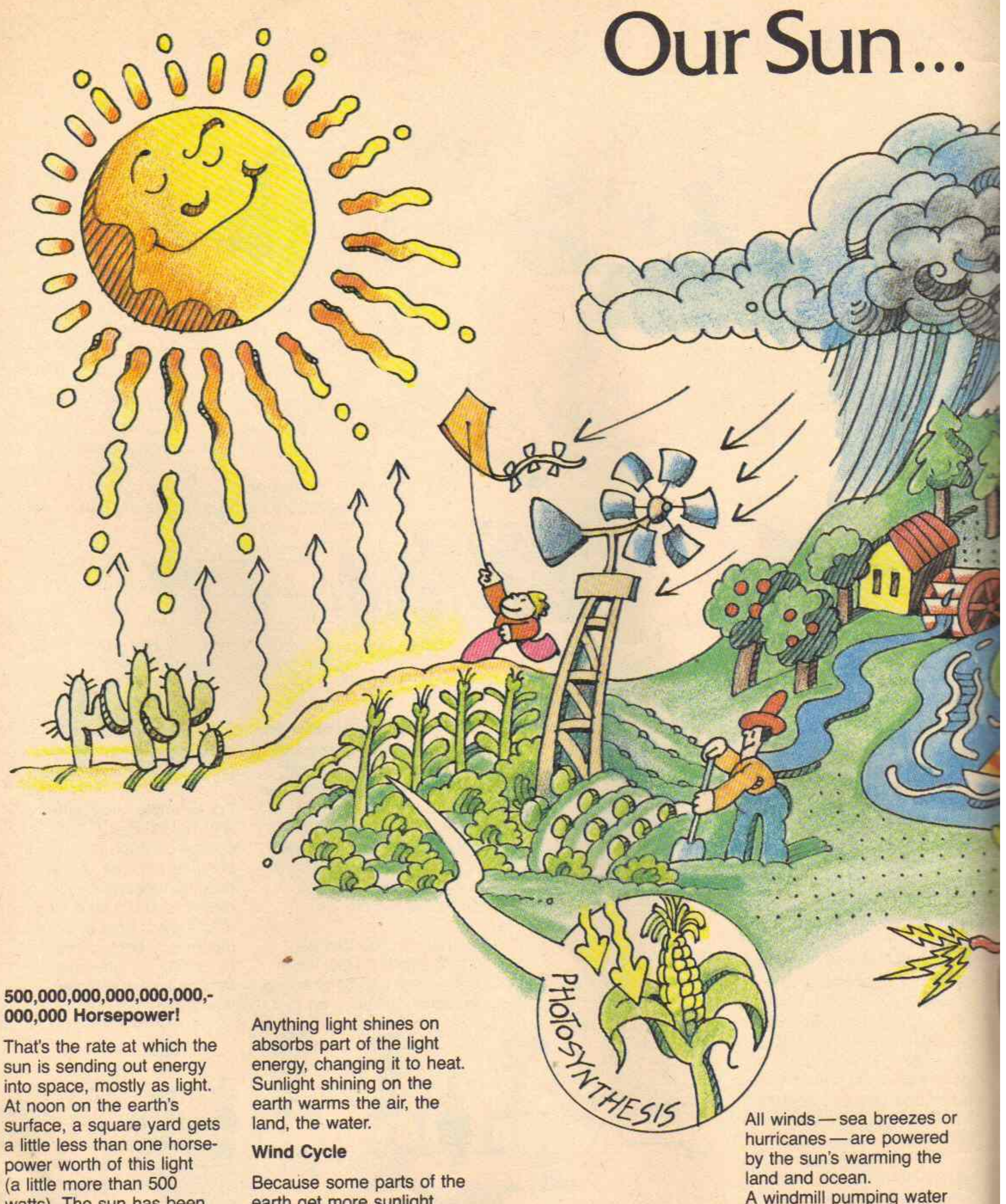
Heat Engines Steam engines, gasoline and diesel engines, steam and gas turbines; all are *heat engines.* All of them change heat to motion. In all of them, heat moves from a hot place (like a boiler or combustion chamber) to a colder place (like a condenser or the air).

No heat engine can be 100% efficient. How much of the heat can be changed to motion depends on the difference between the temperatures of the hot place and the cold place.

For example, an engine with 1000°F gas in the cylinder and room temperature exhaust has a maximum possible efficiency of about 60%. The efficiency of heat engines has mostly been improved by raising the operating temperature; the higher the better.



Our Sun...



500,000,000,000,000,000,000,000 Horsepower!

That's the rate at which the sun is sending out energy into space, mostly as light. At noon on the earth's surface, a square yard gets a little less than one horsepower worth of this light (a little more than 500 watts). The sun has been putting out energy at this rate for the last 4 billion years, and will probably go on doing it for another 4 billion years.

Anything light shines on absorbs part of the light energy, changing it to heat. Sunlight shining on the earth warms the air, the land, the water.

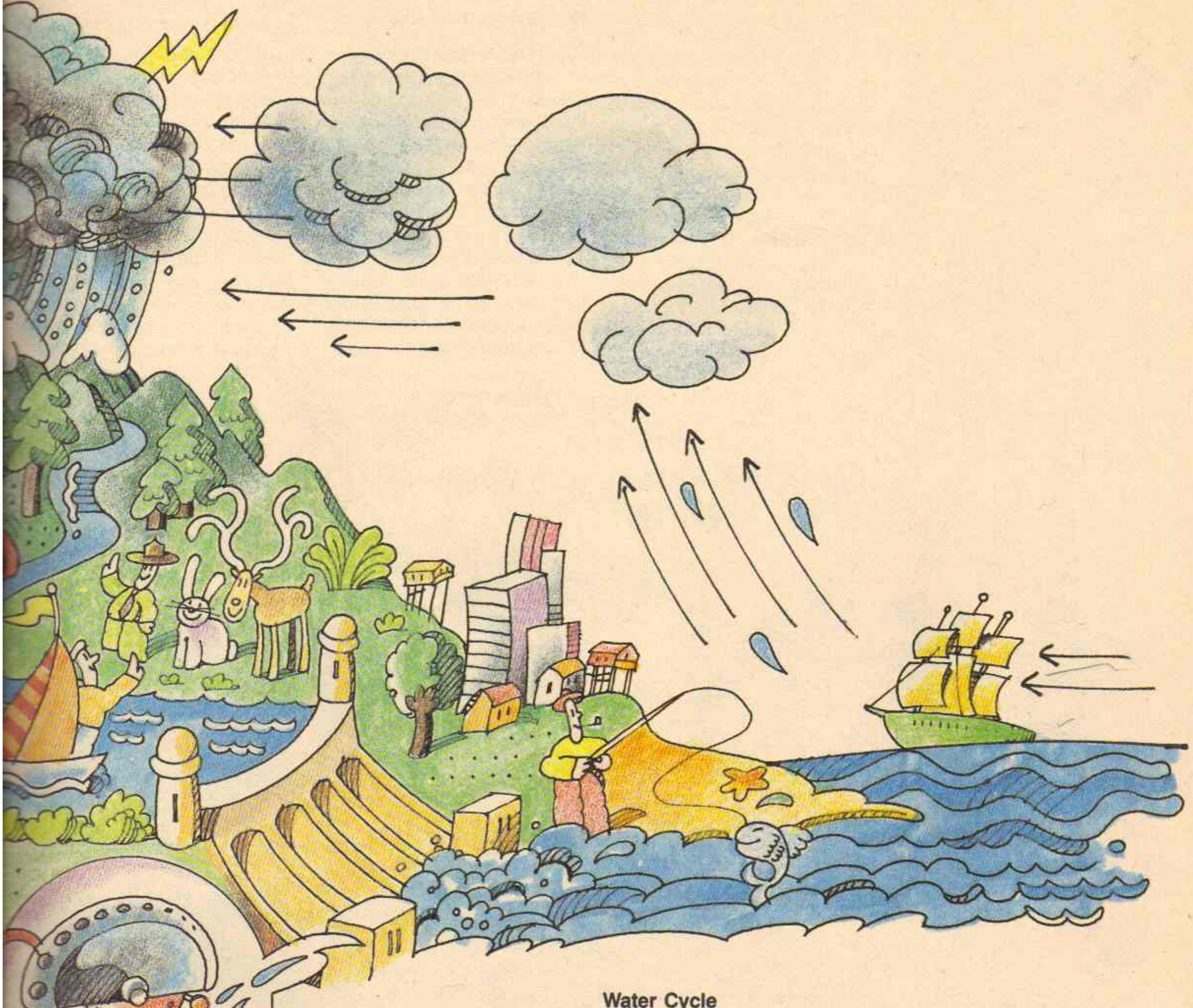
Wind Cycle

Because some parts of the earth get more sunlight than others, they are hotter. Air over warm land and sea areas is heated and rises, and colder air comes in to take its place.

All winds — sea breezes or hurricanes — are powered by the sun's warming the land and ocean.

A windmill pumping water on a Texas ranch; the ship that brought Columbus to the New World — the energy for these came from sunlight.

energy superstar



Photosynthesis

is the process green plants use to store light energy, in the form of the chemical energy we call food. All the energy of our bodies comes from food, and so from sunlight that once struck a green leaf.

Water Cycle

When sunlight warms water, it helps some of the water evaporate. The water vapor is blown about by the wind, and sometimes makes clouds and falls as rain. The rain water collects in rivers and rushes down to the sea, to be lifted again as water vapor to the mountaintops. The electrical energy we get from hydroelectric plants, like Hoover Dam, was once the energy of sunlight.

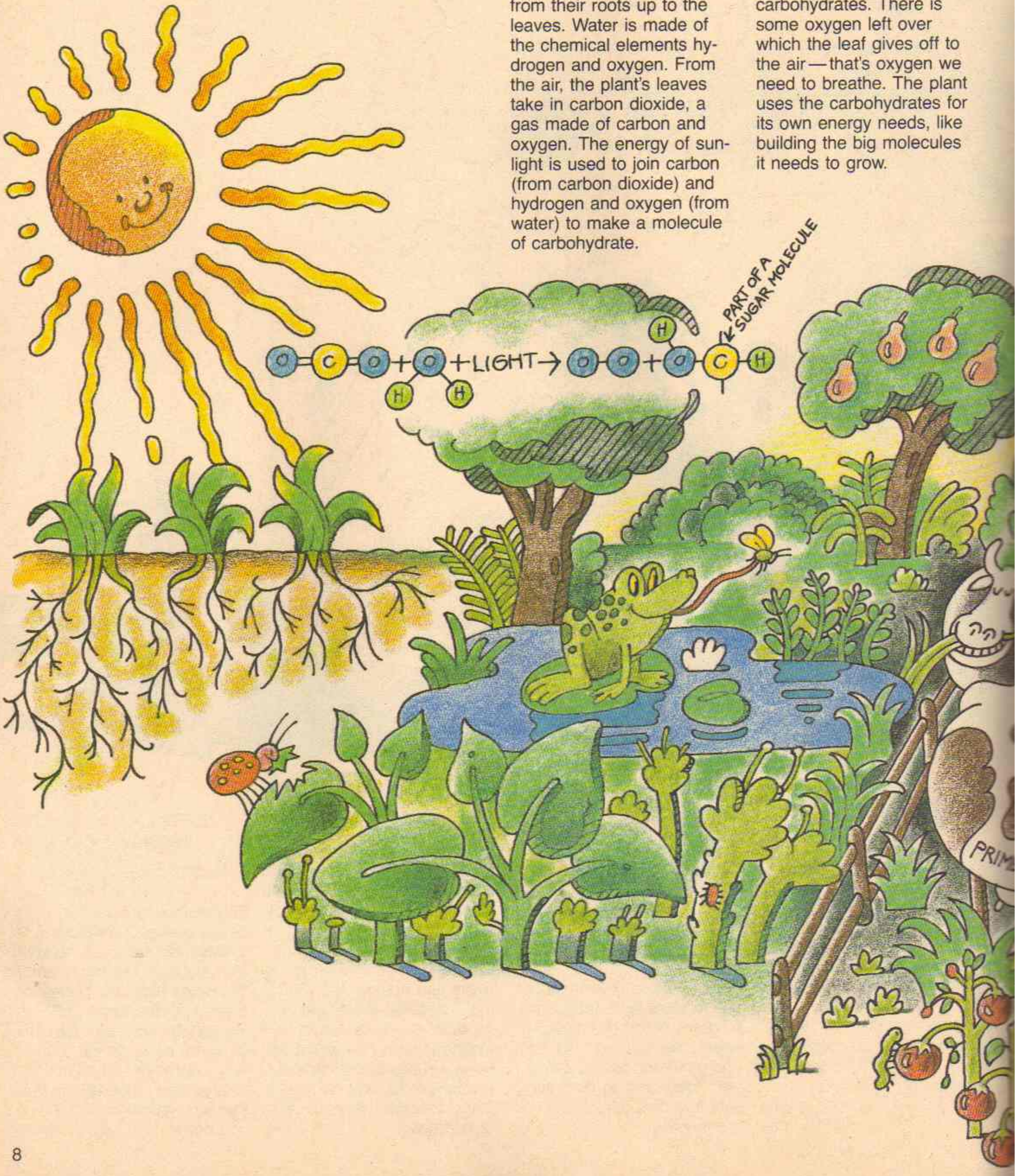
The sun's energy is the power behind the natural cycles that make our world the way it is. The rivers run, the winds blow, the seasons change, generations of living things succeed each other, all because the materials are recycled and the energy flows from a sun that just keeps on sending us energy.

...provides

How Plants Trap Energy

Green plants bring water from their roots up to the leaves. Water is made of the chemical elements hydrogen and oxygen. From the air, the plant's leaves take in carbon dioxide, a gas made of carbon and oxygen. The energy of sunlight is used to join carbon (from carbon dioxide) and hydrogen and oxygen (from water) to make a molecule of carbohydrate.

Sugars and starches are carbohydrates. There is some oxygen left over which the leaf gives off to the air — that's oxygen we need to breathe. The plant uses the carbohydrates for its own energy needs, like building the big molecules it needs to grow.


O=C=O + O H H + LIGHT → O-O + O-C-H H
PART OF A SUGAR MOLECULE
PRIM

Food Energy

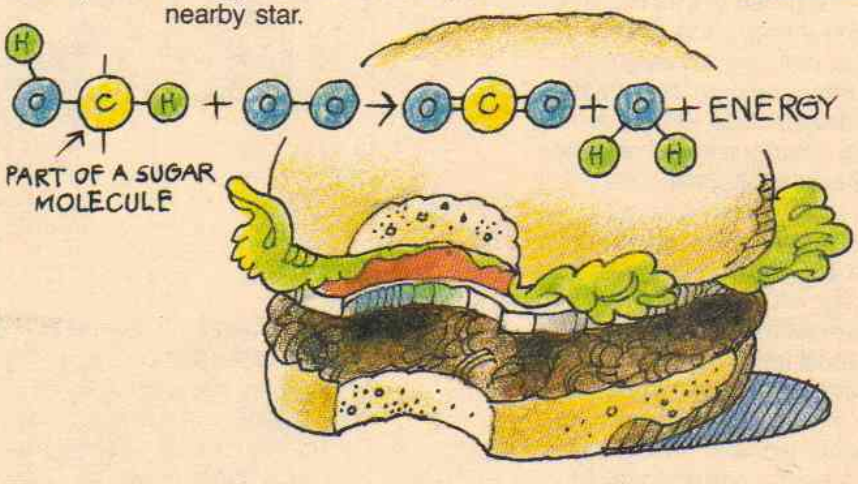
Passing Energy Along

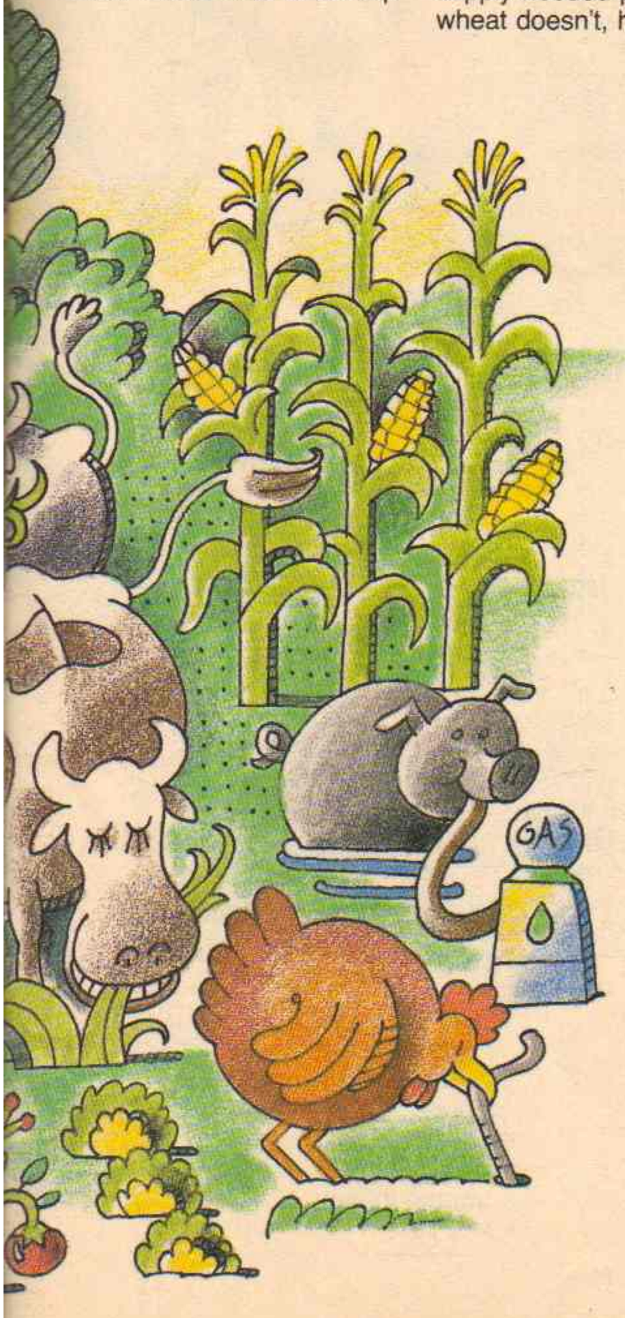
The molecules of the plant are stored chemical energy. If an insect comes along and eats the leaf, it gets the chemical energy that was in the plant's substances. It may use part of that energy to fly to the next leaf, or it may be eaten by a bird, who gets the chemical energy in the insect's substances. This passing along of food energy from plant to animal to animal creates a food chain. The animal at the top of the food chain doesn't get all the energy of sunlight the green plants at the bottom of the food chain took in. Most of it has been changed to heat by animals along the way.

People are at the top of many food chains. If that chain is wheat-cow-people, you will get only a tenth of the food energy you would have gotten by eating the wheat itself. (Beef does supply needed proteins that wheat doesn't, however.)

Cashing in Your Chips

You get energy out of the food you eat by breaking down big food molecules and adding oxygen to make water and carbon dioxide. Water and carbon dioxide! Isn't that what the plant started with? Yes, people just run photosynthesis backwards to get out the energy that started with light, giving back to the air the carbon dioxide the plants need. When you run, breathe, think or snore, you are using energy that came from our nearby star.

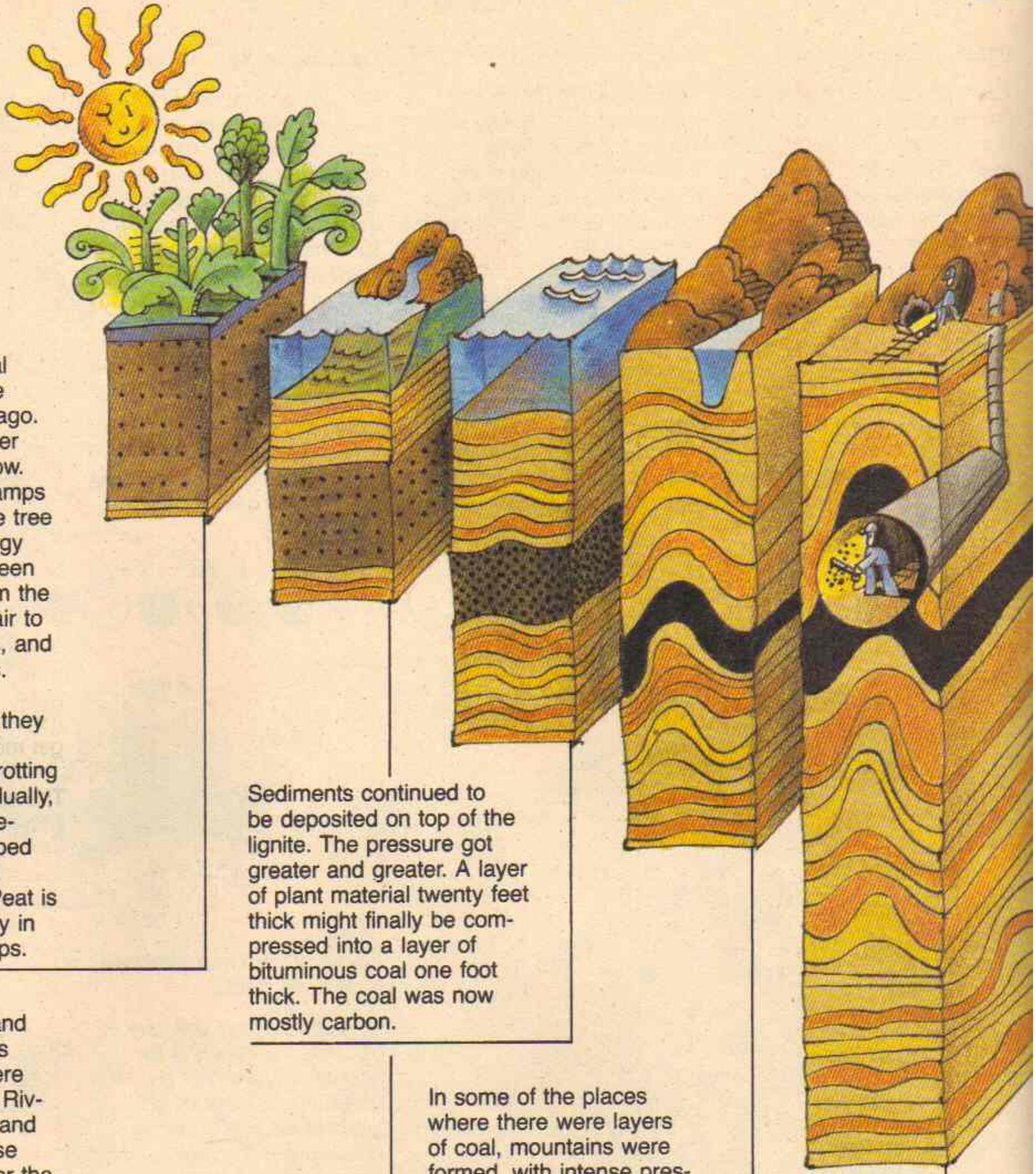




Takes More Than Sunlight to Set the Table

The only energy you can get from your food is the light energy that fell on green leaves. But other kinds of energy go into growing our food and carrying it to our table — about ten calories for every calorie of food energy. On the farm, it takes 3 gallons of petroleum to raise a hog, 3 cups to raise a chicken, and 30 gallons to raise an acre of peanuts. About a fourth of the energy used to feed America is used on the farm. The rest is used to transport, refrigerate, process, dry, package, and cook. Almost all of this energy comes from oil and natural gas.

Fossil Fuels . . . super long



coal

Most of the earth's coal originated around three hundred million years ago. The climate was warmer and wetter than it is now. Many places were swamps where green plants like tree ferns grew. Using energy from sunlight, these green plants took carbon from the carbon dioxide in the air to make sugars, starches, and other plant substances.

When the plants died, they fell into the water. The water kept them from rotting away completely. Gradually, a thick layer of plant remains built up on the bed of the swamp. We call these remains, peat. Peat is still being formed today in some bogs and swamps.

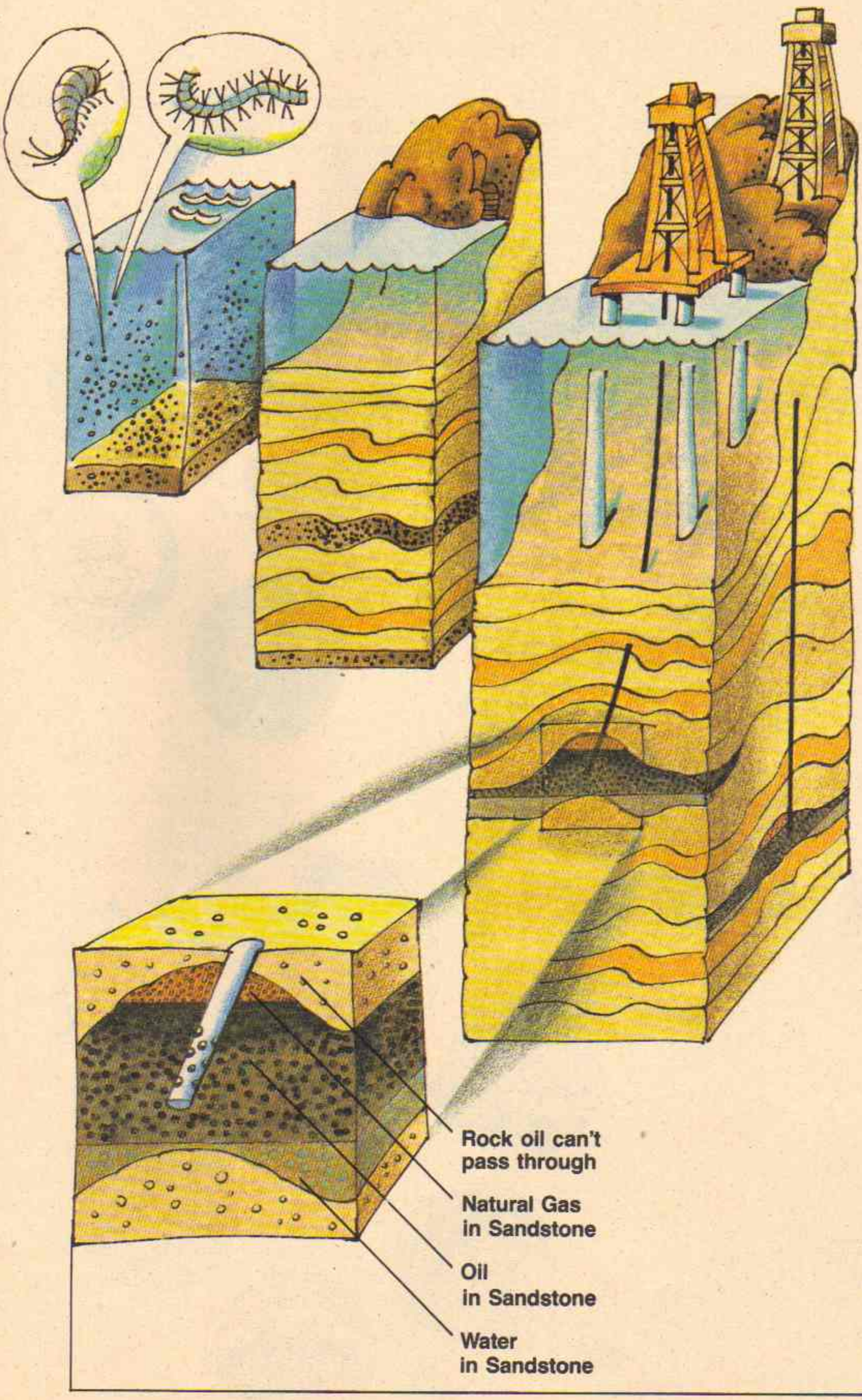
As time passed, the land changed. Shallow seas covered the place where the swamp had been. Rivers swept mud, sand, and clay into the sea. These sediments washed over the layers of peat. The layers of sediments grew thicker as more sand or clay was deposited. The weight of these layers squeezed water out of the peat and hardened it. It became a low-grade form of coal called lignite.

Sediments continued to be deposited on top of the lignite. The pressure got greater and greater. A layer of plant material twenty feet thick might finally be compressed into a layer of bituminous coal one foot thick. The coal was now mostly carbon.

In some of the places where there were layers of coal, mountains were formed, with intense pressure and folding of the rock layers. This created the highest grade coal, anthracite. It is 90% pure carbon.

Today, we are mining the remains of green plants that grew before there were dinosaurs. The energy we get by burning coal comes from sunlight that fell on a swamp millions of years ago.

stored~up food energy



oil & gas

We don't know as much about how oil and natural gas are formed as we do about coal's formation. This is what most geologists think happened:

The ocean is the home of many floating microscopic plants and animals. (Most of our oxygen supply comes from these green plants, not from land plants.) When these living things die, they may sink to the bottom and get mixed with sediments.

The sediments are covered with more sediments. Eventually, the deeper sediments become rocks like sandstone. Between the grains of sand in the sandstone are tiny spaces. The substances from the animals fill these spaces.

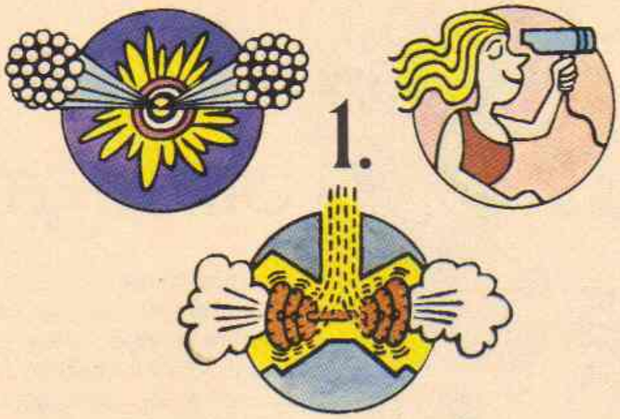
Heat and pressure change the plant and animal remains. Part often becomes natural gas dissolved in the crude oil. The different substances from different plants and animals, and different heats and pressures in the earth, explain why crude oil is such a jumble of hundreds of different chemicals.

Today, we drill down to reach a sedimentary rock in which oil might be trapped. One of the clues geologists use to locate oil are the fossils of ocean animals in the surrounding rock layers.

Let's Review:

Energy Flows

Each small drawing below represents a step in an energy flow. (Not all the steps in the flow are shown.) In each group of pictures, draw arrows from circle to circle to show the energy flow.



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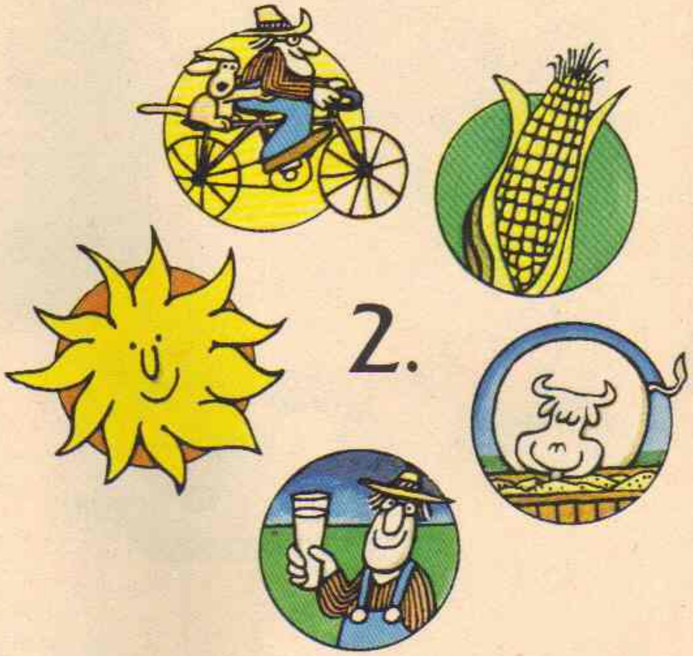

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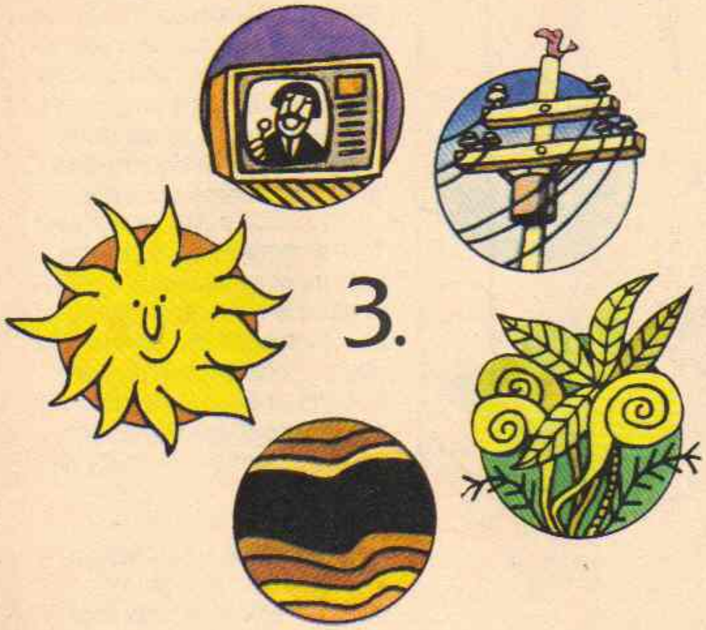

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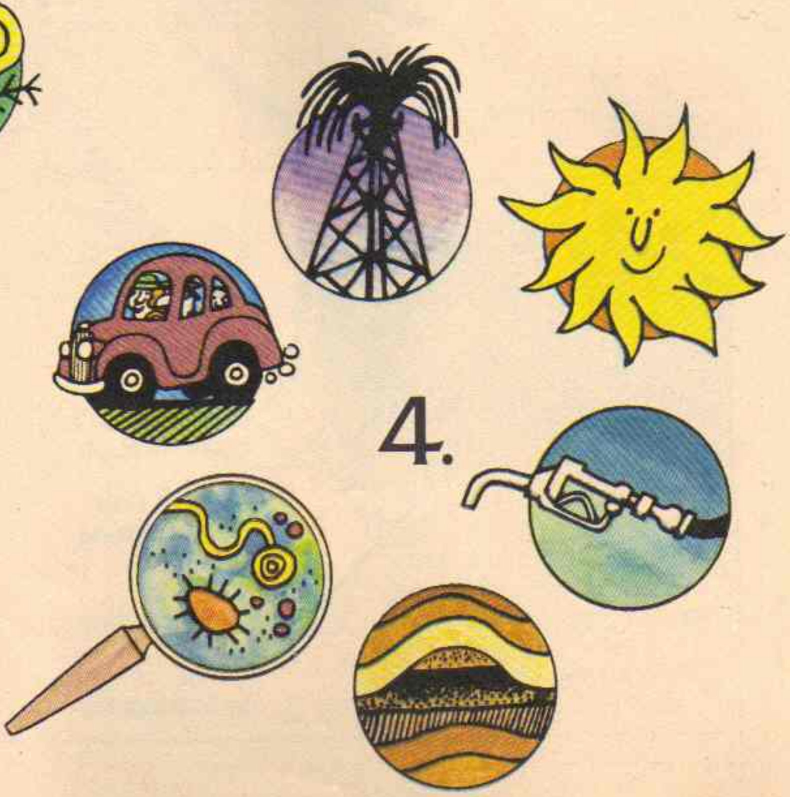

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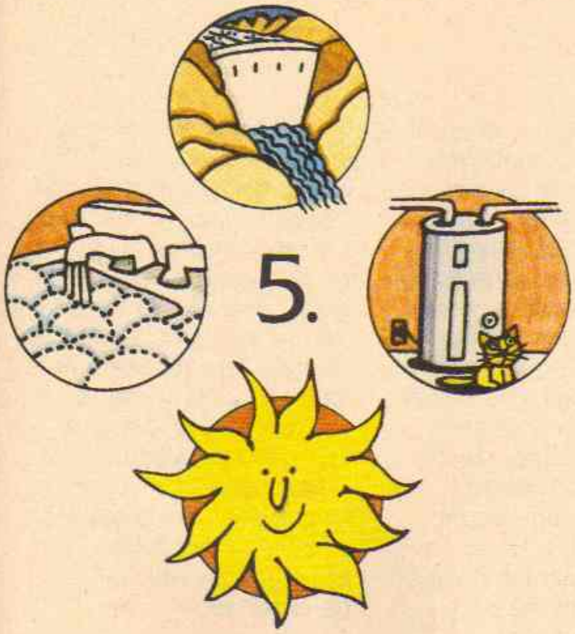


Efficiency

7. A heater was used to heat a room. Some of the heat went into the air in the room, and the rest went up the chimney and was lost. The efficiency of the furnace was 50%. If it put 10,000 joules of energy into the air in the room, how much energy went up the chimney? ____________ joules.

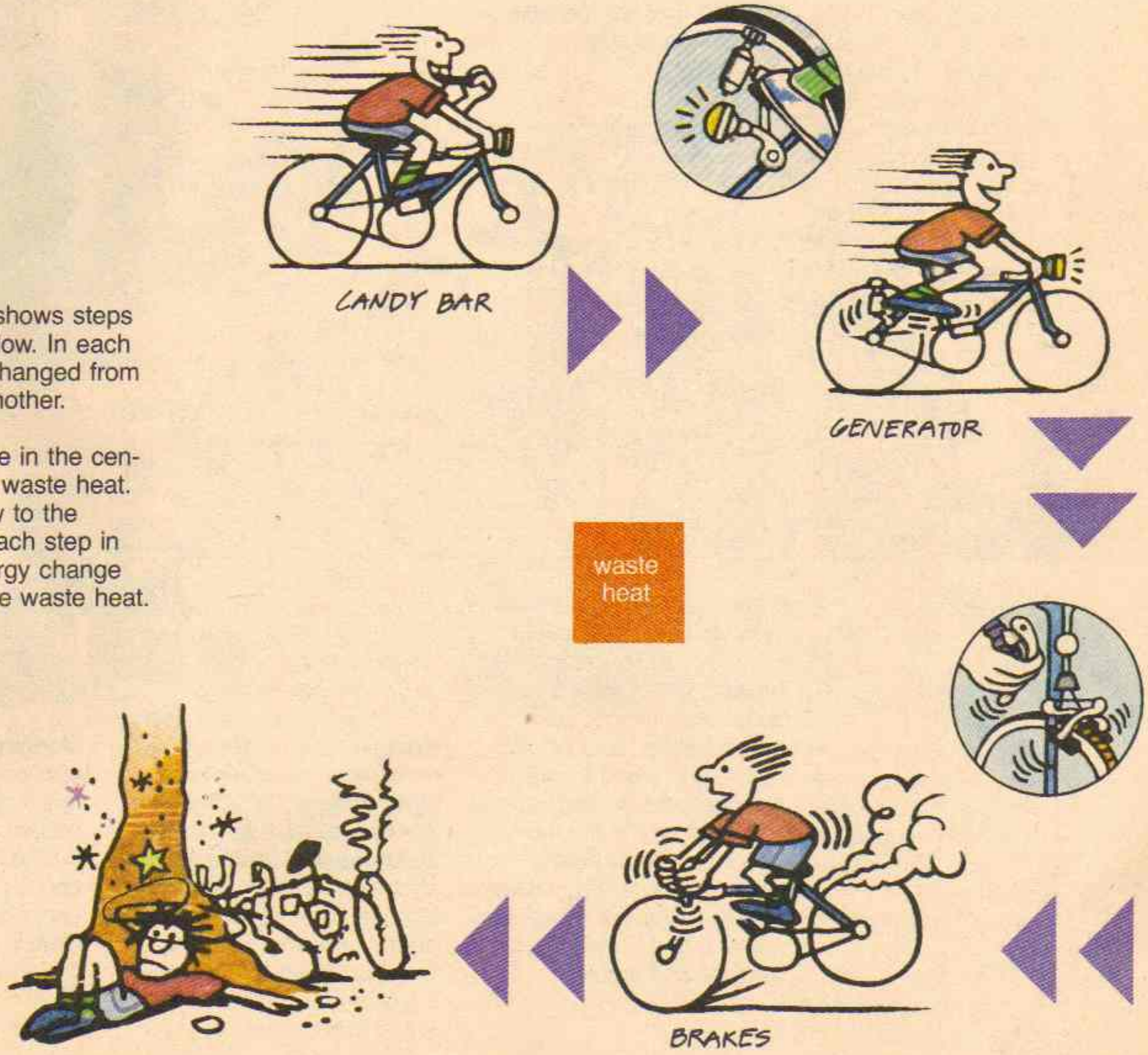
8. A machine in a factory had an efficiency of 10%. The energy to run it for a year cost $8,000. If the machine could be made 40% efficient, how much would the energy to run it for a year cost? (Circle one.)

$200 $2,000 $3,200 $8,000 $32,000

Heat

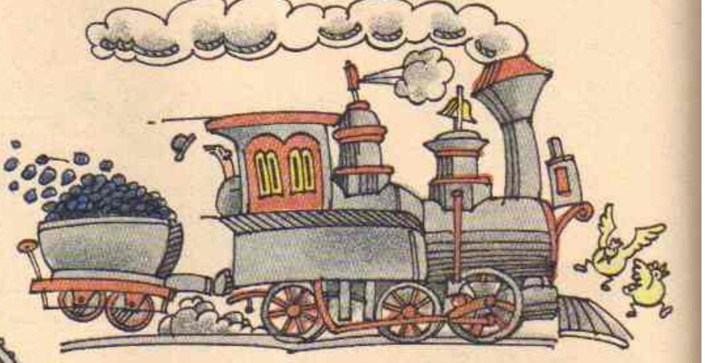
6. This diagram shows steps in an energy flow. In each step, energy changed from one form to another.

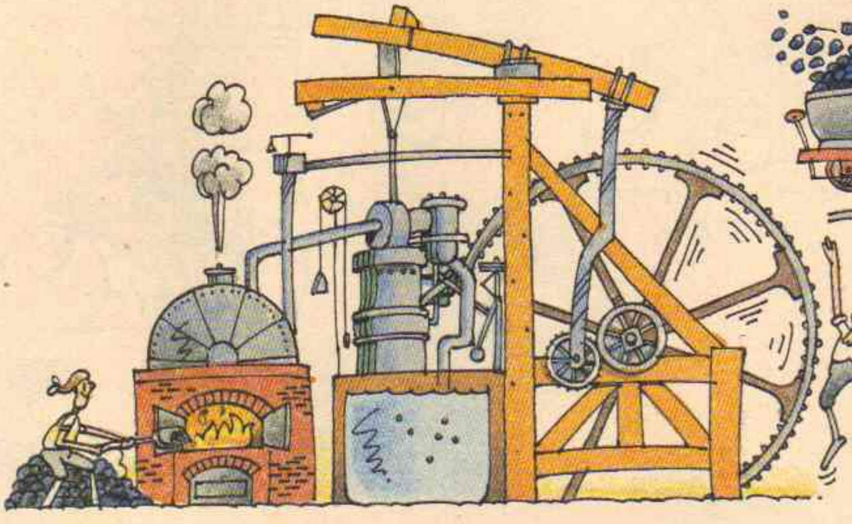
The red square in the center represents waste heat. Draw an arrow to the square from each step in which the energy change produced some waste heat.

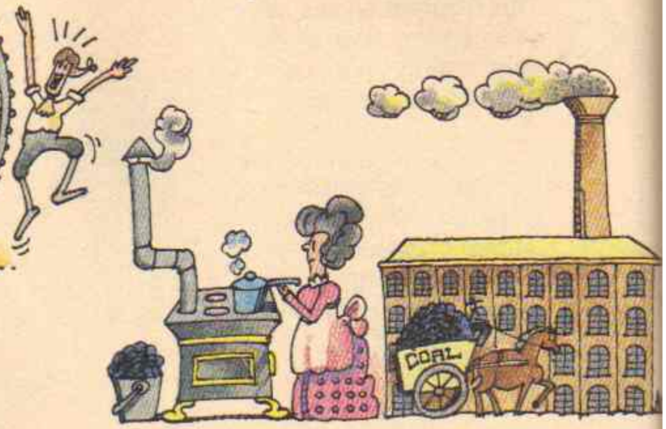


Coal: the once and

About 650 years ago, an English king named Edward I made a clean air order. Whenever Edward's officials visited London, they complained of the terrible smells coming from the workshops of the blacksmiths and the people who heated limestone to make lime for mortar. The stench came from the burning of a stone called sea-coal. So Edward forbade the burning of coal.







But people still wanted lime. They needed knives and horseshoes. To get the high temperatures needed to make such things, you needed either coal or charcoal — and wood to make charcoal was getting scarcer and scarcer. Finally the law was changed to permit the burning of coal. People were able to make the things they wanted, and London got smokier and smokier.

Charcoal was also needed to make iron from its ore. Around 1709, an English ironmaster named Abraham Darby perfected a way of using coal to make good pig iron. His method spread slowly, and others added their ideas. By 1800, the English had mastered ways of making iron and steel using coal. Cheap, plentiful coal made iron plentiful, and plentiful iron—strong, tough, durable—led to an explosion in people's use of tools and machines.

Coal powered a second revolution: the steam engine. Around 1780, inventors like James Watt began to build practical machines that changed the heat from burning coal into mechanical energy. For the first time, a way had been found to make a fuel do the work instead of muscles.

In the United States, coal got off to a slow start. Our vast virgin forests provided a plentiful supply of cheap fuel wood; not until 1883 did we burn as much coal as wood. Railroads were the biggest single cause of this change. They needed steel for tracks and rolling stock, and fuel for locomotives. The railroads also helped increase coal consumption by carrying coal cheaply to all parts of the nation, and to ports from which it could be exported.

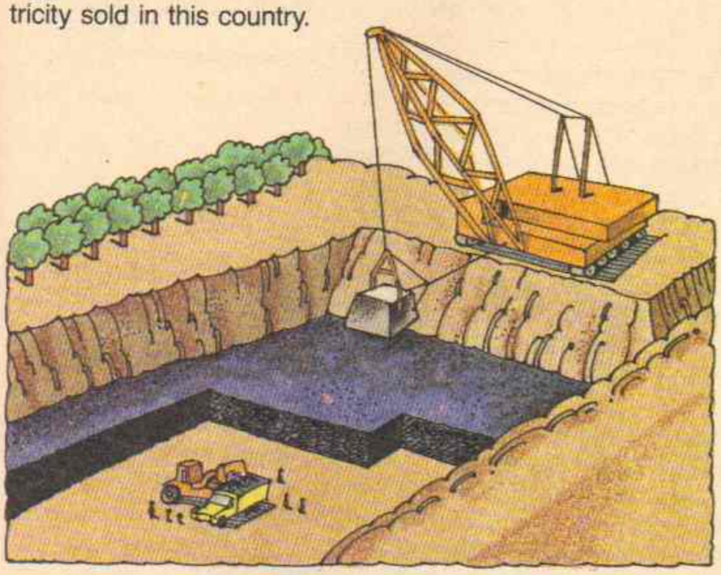
Modern times were built with coal. Coal ran the factories and moved the people and freight. In pot-bellied stoves, it heated country stores, and it cooked meals in homes. Coal was king!

future king?

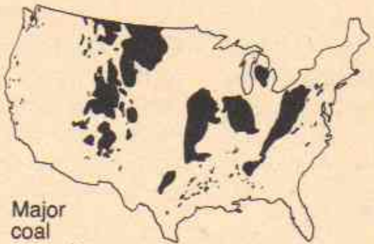
In the 1950s, coal was replaced as our chief energy source by oil and—increasingly—natural gas, because those fuels are much easier to transport and burn.

Most of the coal we mine today is burned under huge boilers to generate electricity. Coal is by far the biggest source of the electricity sold in this country.

Our country is blessed with a vast supply of coal, enough to last for hundreds of years at the rate we're using it. It is our biggest mineral energy reserve (next to uranium, if that were used in breeder reactors). In the West, large seams of coal lie a few hundred feet below the surface, and are often surface mined.



People like western coal because it has little sulfur. Burning sulfur can cause air pollution. Most eastern coal is high in sulfur and lies deeper in the ground, so that it has to be mined underground. Underground mining is less efficient than surface mining, even including the need to reclaim the surface land when the mine is closed. However, new underground mining methods have been developed that get out more of the coal than we used to, with less danger to the miners.



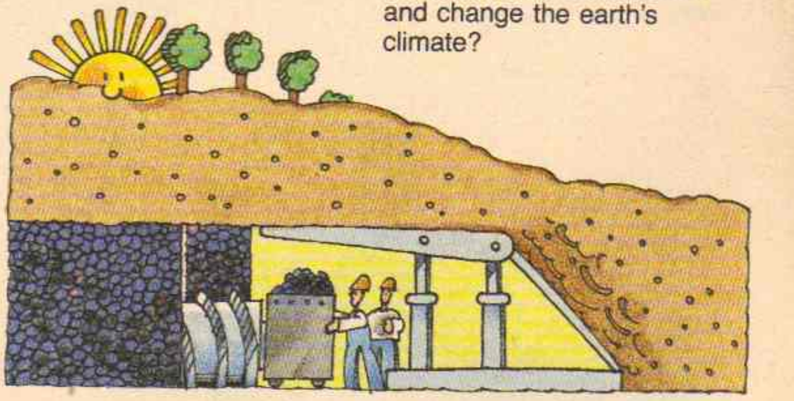
Major coal deposits in the U. S. A.

Since we have so much coal—perhaps 50 times more coal than oil—why don't we use more of it? In the short run, one reason is that to open new coal mines and build coal-burning equipment is a costly, time-consuming business. In the long run, the big problems are how hard it is to move and burn coal—and pollution.

New ways of shipping coal more cheaply, even by pipeline, are being tried. In pilot plants, we are making other fuels from coal, such as gasoline and pipeline gas. Such fuels would be easier to move and burn than coal itself. But the processes we now have make fuels that cost more than we're paying today. Can cheaper processes be found?

New ways of burning coal, like fluidized bed combustion, promise less pollution and hotter, more efficient fires, and will make it easier to burn coal in small plants. Can these techniques be proven commercially?

Air pollution equipment is removing most of the pollution that once darkened industrial cities. But the problem of cleaning up coal at an acceptable price is not yet solved. In the long run, the most stubborn pollutant may turn out to be carbon dioxide. Is what many scientists fear true? Will relying on coal increase the percentage of this gas in the atmosphere and change the earth's climate?



For decades, coal has been ignored. Now we need to find answers to questions like these as soon as possible. If we can, perhaps one day coal will be king again.

Oil & Gas Production & Consumption

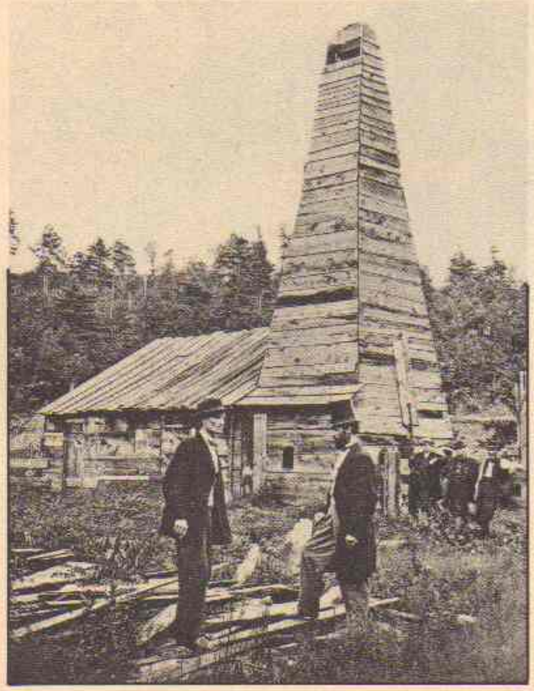
In 1850, artificial light was expensive. Most people used lamps that burned turpentine, alcohol, lard oil, oil made by heating coal, or, best of all, clean-burning whale oil. Unfortunately, a gallon of whale oil cost two days' wages.

In some places in the earth, an oily substance seeps to the surface of creeks and pools. Some manufacturers who made lamp oil by distilling coal tried distilling this "rock oil." It made a fine lamp oil, but skimming it off creeks was too difficult.

Brine well drillers tried a different way of getting the "petroleum." In 1859, in Pennsylvania, they struck oil at 69½ feet. Drilling for oil was the cheapest way the world had ever found of getting a concentrated energy source.

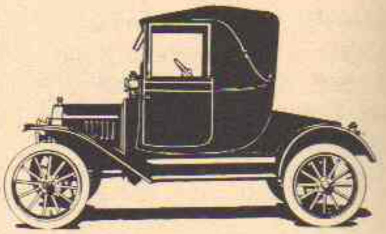
Crude oil is a complex mixture of many different substances. Refiners separated them by distilling the oil. The useful part, kerosene, was sold for lamps. The useless parts, like gasoline, were mostly thrown away.

Courtesy Drake Well Museum



Oil production boomed. People from China to Peru wanted kerosene for their lamps. American oilmen sold it to them. America became the leader in oil production, refining, and shipping know-how, a role we still have.

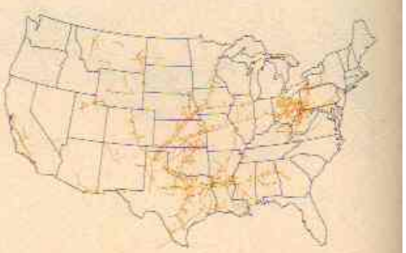
Times changed. Electric lights were invented. The horse began to be replaced. Horseless carriages needed a powerful fuel that could be burned in a lightweight engine. Gasoline was tried and it worked. Henry Ford's cheap Model T put America on wheels.

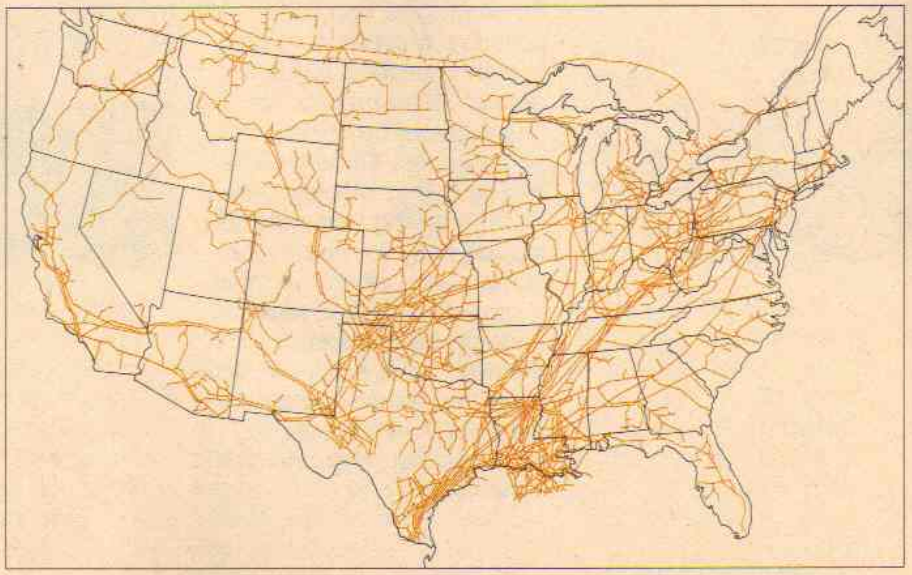


Now people wanted more gasoline, less kerosene, from the crude oil. Refiners asked chemists to find ways of remaking the crude oil molecules into the molecules people wanted to buy. The chemists did, and went on to invent ways of making new substances from petroleum. In the 1930s appeared synthetic rubbers like neoprene, synthetic fibers like nylon, and plastics like polystyrene. The refinery became a more and more complicated chemical factory.

Where oil was found, natural gas was also, but it was harder to get gas to market. Mile by mile, pipelines were built from the oil fields to the nation's homes and factories. Clean-burning natural gas began to replace coal.

The two maps below show principal natural gas pipeline systems in the United States for 1935 and 1978.





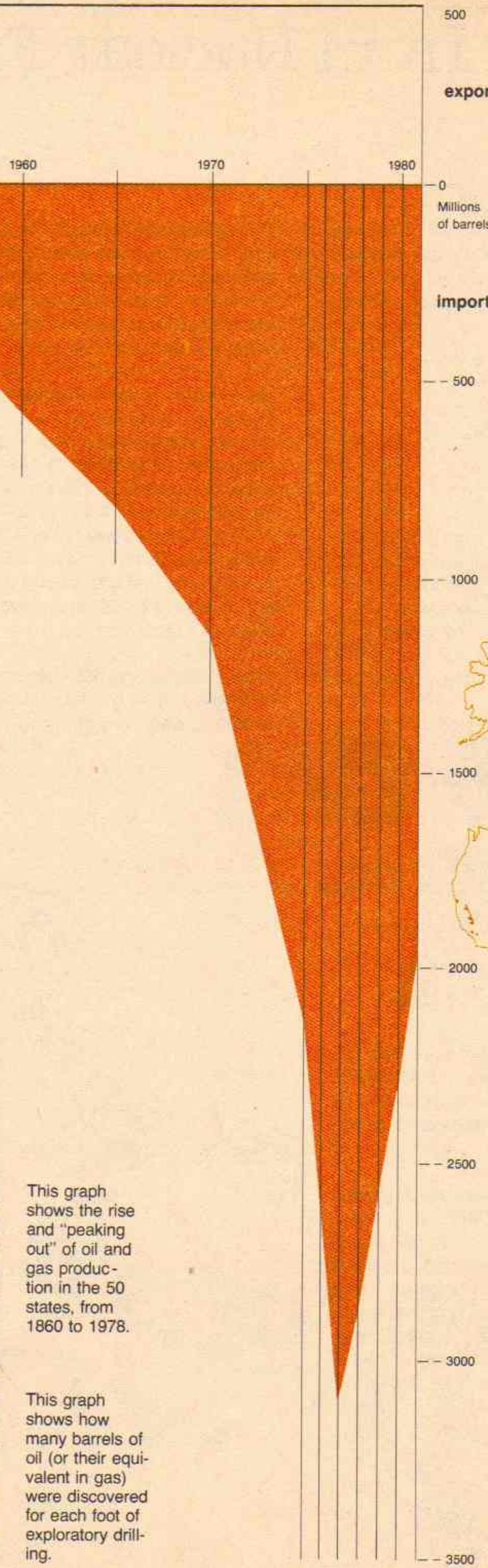
USA 1859-1981

In the years after World War I, and again after World War II, we seemed to be running out of oil. Prices rose. Drilling increased. Huge new fields were found in Texas, and shortages disappeared.

By 1947, the U.S. was using so much petroleum that it was buying more from other countries than it was selling to them. In 1971, for the first time, the year's production of oil in the U.S. was less than it was the year before. In 1979 we imported 44% of the oil we consumed. Prices rose.

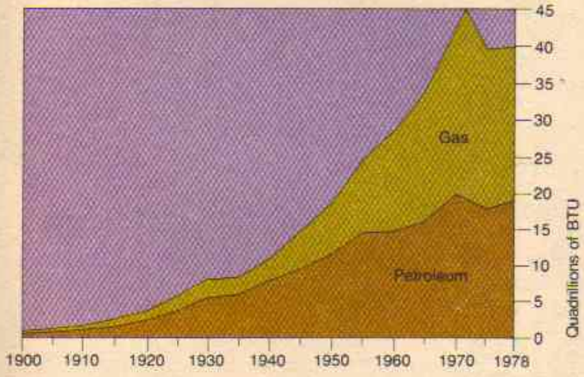
Since mid-1979, the number of drilling rigs at work has gone up 50%. But so far, no big new fields have been found. Reserves—the oil we know is there but haven't pumped out yet—continue to decline.

Our country is one of the first to have its oil production peak, because our oil fields were among the first to be discovered, and among the fastest developed. Most of the easy oil is gone. Billions of barrels remain to be recovered, but many will be expensive to get. They will come from hostile environments, like the arctic coast of Alaska or the floor of the sea, and from enhanced recovery techniques like blowing hot steam and detergents down old wells to recover more of the oil.

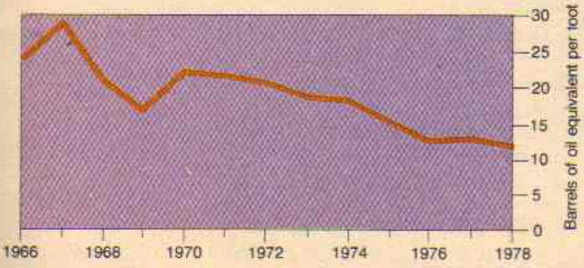


This graph shows how the U.S. changed from a net exporter of oil to a net importer.

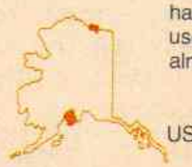
In the years before 1880, U.S. exports filled more than 80% of other countries' demand for oil, but the amount was too small to be visible on this graph. From 1885 to 1929, U.S. exports provided about a third of the rest of the world's needs, and the U.S. was the biggest exporter. By 1947, we consumed more oil than we produced. Today, we import about half the oil we use, and export almost none.



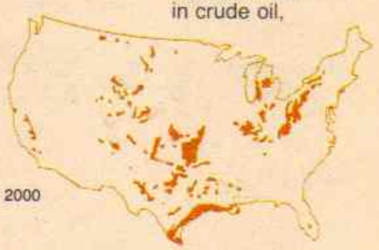
This graph shows the rise and "peaking out" of oil and gas production in the 50 states, from 1860 to 1978.



This graph shows how many barrels of oil (or their equivalent in gas) were discovered for each foot of exploratory drilling.



US oil fields.

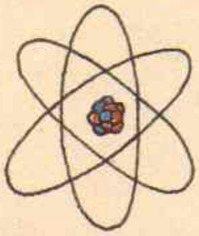


Counting natural gas as its heating equivalent in crude oil, geologists estimate that there are 49 billion barrels of proved reserves, inferred resources, and undiscovered resources in Alaska, 75 offshore in the U.S. and Alaska, and 203 Bbbls on land in the "lower 48."

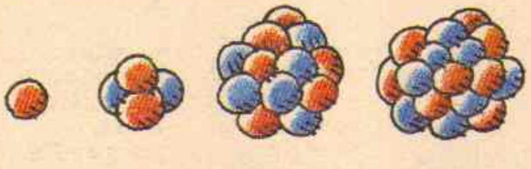
The actual amount of oil and gas that will be recovered depends on how much it is worth to us. The higher the price, the greater the quantity that is economically recoverable.

Energy from Nuclear Fission

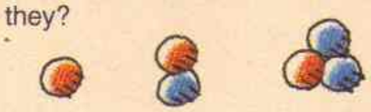
Almost everything is made out of tiny bits of matter called atoms. An atom has two parts: in the center a **nucleus,** and around the nucleus a cloud of constantly moving **electrons.** This is one kind of diagram of an atom:



The electrons are very important in ordinary chemical reactions like burning, but "atomic" energy comes from changes in the nucleus. The nucleus contains two kinds of atomic particles: the proton ● and the neutron ●. The number of protons in a nucleus decides which chemical element the atom is.

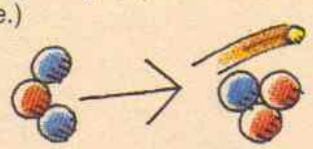


Here are three nuclei. What element are they?



They are all hydrogen, because they all have one proton. Yet they are different, because they have different numbers of neutrons. We call these **isotopes** of hydrogen.

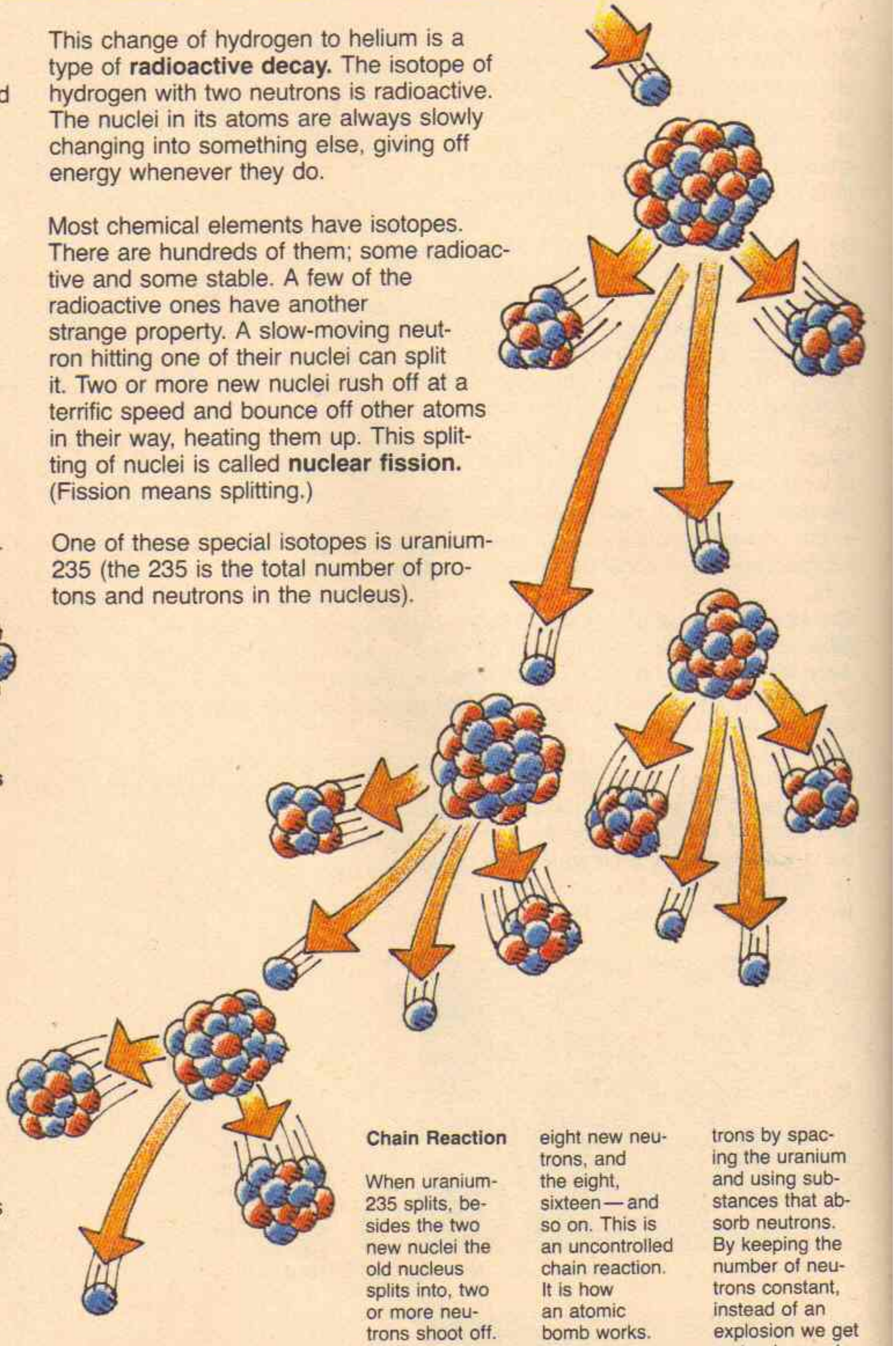
The hydrogen isotope with two neutrons does an amazing thing: without warning, one of these nuclei can suddenly change into another element. One of the neutrons disappears, and a proton appears. Since the new nucleus has two protons, it is helium, not hydrogen. At the same time, an electron shoots out of the nucleus at very high speed. (This electron used to be called a beta ray. Since it really isn't like a ray of light, we now call it a beta particle.)



This change of hydrogen to helium is a type of **radioactive decay.** The isotope of hydrogen with two neutrons is radioactive. The nuclei in its atoms are always slowly changing into something else, giving off energy whenever they do.

Most chemical elements have isotopes. There are hundreds of them; some radioactive and some stable. A few of the radioactive ones have another strange property. A slow-moving neutron hitting one of their nuclei can split it. Two or more new nuclei rush off at a terrific speed and bounce off other atoms in their way, heating them up. This splitting of nuclei is called **nuclear fission.** (Fission means splitting.)

One of these special isotopes is uranium-235 (the 235 is the total number of protons and neutrons in the nucleus).



Chain Reaction

When uranium-235 splits, besides the two new nuclei the old nucleus splits into, two or more neutrons shoot off.

Those two neutrons can hit two more nuclei, making them split, producing four neutrons, and those four can produce eight new neutrons, and the eight, sixteen—and so on. This is an uncontrolled chain reaction. It is how an atomic bomb works.

Instead of letting the neutrons multiply like rabbits, 2, 4, 8, 16, 32, 64, 128, and so forth, we can control the number of neutrons by spacing the uranium and using substances that absorb neutrons. By keeping the number of neutrons constant, instead of an explosion we get a steady supply of heat.

That is the basic idea behind using nuclear energy to get power.

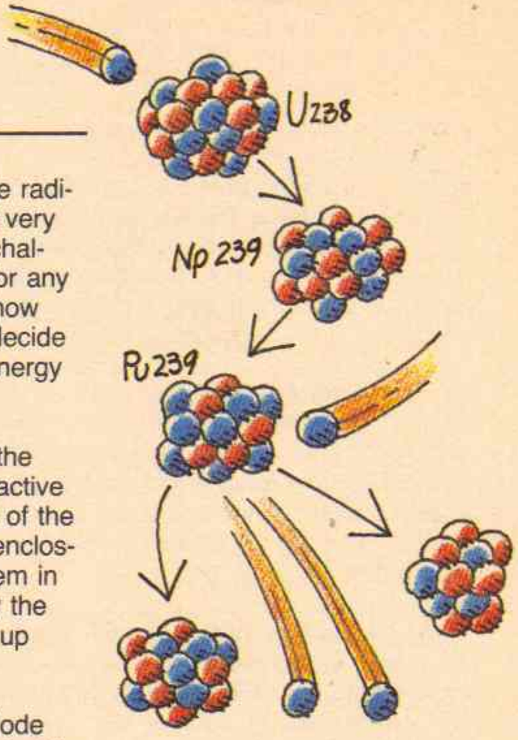
Compared with other ways of making electricity, nuclear fission has some definite advantages. There is no smoke or carbon dioxide. Fewer workers are killed in accidents. Nuclear electricity may be a little cheaper than its main competitor, coal. Probably the biggest advantage is that we have the fuel and know how to get large amounts of electricity from it.

Nuclear power is controversial mainly because of concern about the effects of radioactivity. Radiation can change the molecules in living cells that contain the code for making new cells. Such a change can sometimes lead to a cancer or birth defect years later.

We receive natural radiation all the time, from sources like cosmic rays and the radioactivity of building materials. Reactors add to this radiation by routinely releasing low-level radioactivity (so do coal-burning power plants). The amount each person gets from such planned releases is hundreds of times less than they get from natural radiation, or from other man-made sources like medical X rays. That the radiation is at such a low level makes it very difficult to measure its effects. The challenge in evaluating nuclear energy (or any other energy source) is to estimate how many people it might harm, and to decide whether the good we get from the energy is worth it.

Some of the materials produced as the reactor operates remain highly radioactive for centuries. They must be kept out of the environment. Storage systems, like enclosing materials in glass and storing them in salt mines, have been planned. Only the government has the authority to set up such a system, and so far it hasn't.

Today's nuclear reactors cannot explode like an atomic bomb. The worst imaginable accident would be a "breach of containment," in which both the steel and concrete shells of an operating reactor would crack and release radioactive materials, producing an effect like fallout from an atomic bomb, perhaps worse. Engineers who design reactors try to make this impossible. There has never been a breach of containment in a commercial power reactor.



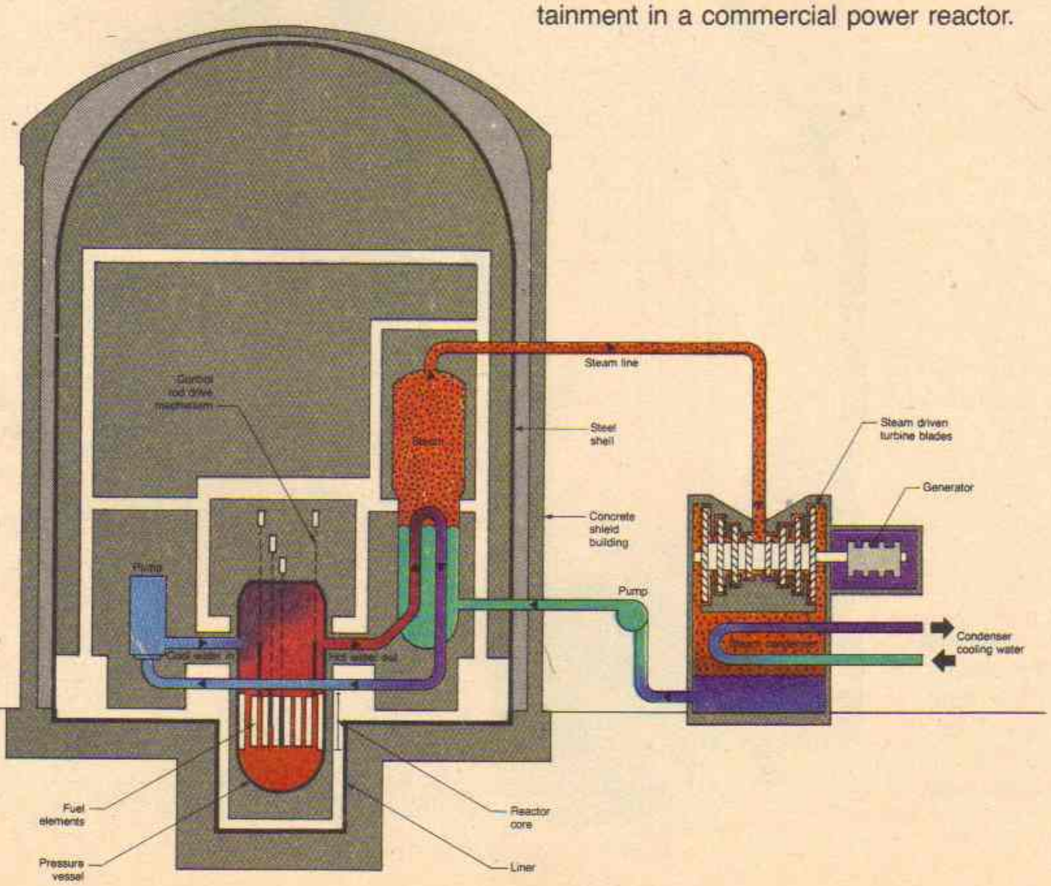
Breeding New Fuel

Uranium-235 is a very rare isotope. Less than 1% of natural uranium is U-235; the rest is another isotope called uranium-238.

Unfortunately, uranium-238 can't be split by slow-moving neutrons, and so is no good as fuel. But when a nucleus of uranium-238 is hit by a fast moving neutron, it changes to neptunium-239, which quickly turns to plutonium-239.

Plutonium 239 can be split by neutrons. So we can use extra neutrons from a reactor to change a substance that can't be used as fuel into a fuel.

Such a reactor is called a breeder reactor.



Pressurized-Water Reactor

Commercial nuclear reactors use the heat from splitting atoms to make steam. The steam is used to run a turbine and generator, just as it is in a coal-burning power plant.

As the plant operates, the fission fragments left over from split uranium atoms accumulate in the fuel. Unfortunately, many of these new nuclei are good at absorbing neutrons, and so stop the reaction. So the fuel must be replaced before all the uranium-235 nuclei have fissioned.

Energy for the Next Ten Thousand Years

In the next ten years, we will not run out of any energy source. Experts think that in the next hundred years world production of oil will decline. In the next thousand years we could run out of coal. And in billions of years, the sun will go out.

We live in the Age of Fossil Fuels, a blip in human history. Yet thanks in part to energy from fossil fuels, in these few centuries the people with fuel have greatly improved their standard of living, learned more, and invented more than in all human history before that.

Many people feel that it is only fair for us to figure out, in the years of fossil fuel abundance that are left, how future generations can use the energy sources that they will have.

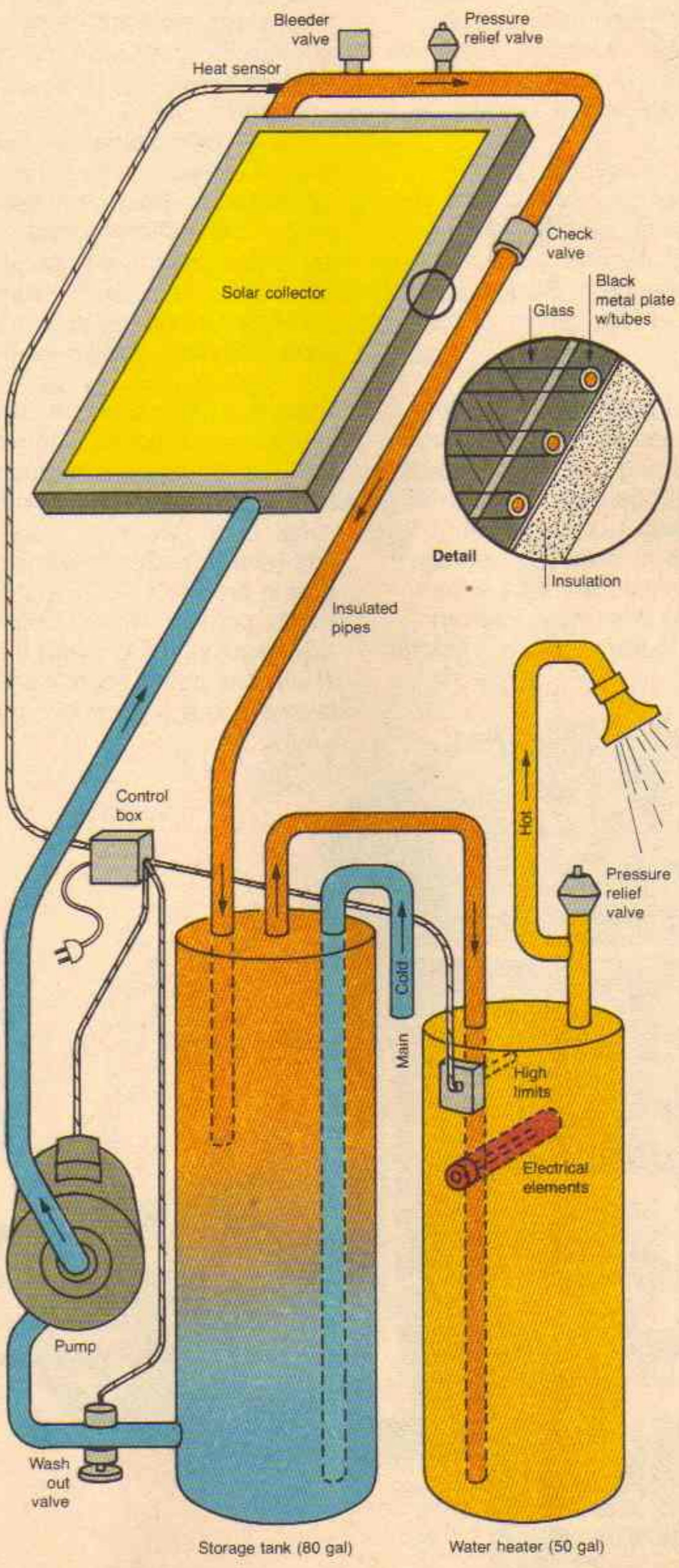
Sunlight is the basic renewable energy source. Eighty years ago, people were building solar collectors. But a solar collection system costs more to build than a furnace producing the same amount of heat. As oil and gas became cheaper and easier to buy, collectors were scrapped.

Today, solar energy is coming back. The prices of fossil fuels are rising, and people are learning cheaper ways of catching the energy of sunlight. No matter where you live, the question is not whether solar energy works, because it can be made to work anywhere, but how much it would cost.

Different energy sources are suited to different uses. Making steel requires very high temperatures and also the element carbon, so coal is ideal. Gas can provide very high temperatures and is clean-burning in simple equipment, so it is a perfect fuel for small urban businesses that need high temperatures.

What is sunlight best suited for? It is easiest to make it provide 70° to 120°F heat. This is very valuable, because almost 70% of the energy consumed in American homes is used to produce low-temperature heat to warm rooms and heat water. If we use sunlight for this, fossil fuels can be saved for uses like running buses and cars.

Active Solar Water Heater



An Active Solar Water Heater
In most parts of the country, solar water heaters can pay for themselves. A typical water heater looks like this:

On the roof is a large, flat black plate. Sunlight warms the plate.

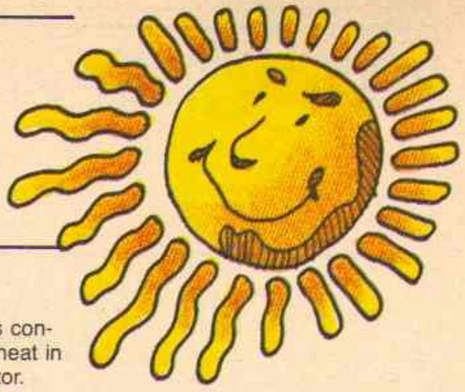
Water circulates through coils in the plate. The flowing water carries away the heat from the plate.

The plate is well-insulated. The insulation on top is clear glass or plastic.

Pumps drive the water to a storage tank in the basement. The storage tank is large and very well-insulated.

A back-up heater that uses electricity or fuel can provide hot water if the storage tank's supply is used up. It is cheaper to do this than to build enough extra collectors and storage tanks to get through the worst possible spells of cold, cloudy, weather.

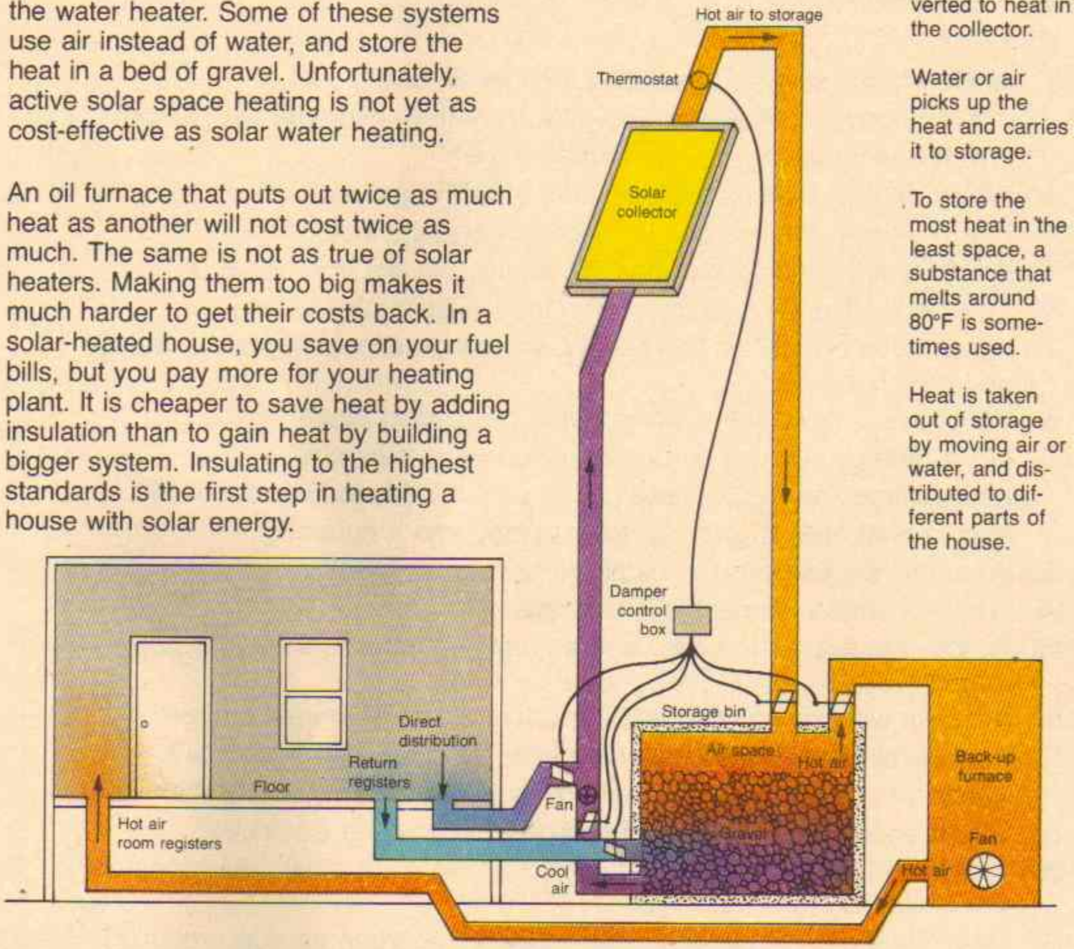
This is called an active system because pumps and controls are used.



Active Solar Space Heating

A house can be heated by a system like the water heater. Some of these systems use air instead of water, and store the heat in a bed of gravel. Unfortunately, active solar space heating is not yet as cost-effective as solar water heating.

An oil furnace that puts out twice as much heat as another will not cost twice as much. The same is not as true of solar heaters. Making them too big makes it much harder to get their costs back. In a solar-heated house, you save on your fuel bills, but you pay more for your heating plant. It is cheaper to save heat by adding insulation than to gain heat by building a bigger system. Insulating to the highest standards is the first step in heating a house with solar energy.



Active
Sunlight is converted to heat in the collector.

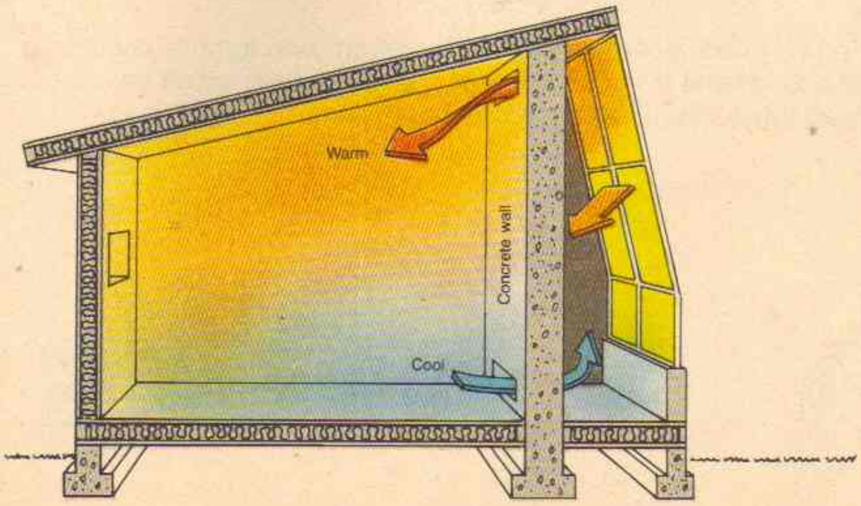
Water or air picks up the heat and carries it to storage.

To store the most heat in the least space, a substance that melts around 80°F is sometimes used.

Heat is taken out of storage by moving air or water, and distributed to different parts of the house.

Passive Solar Space Heating

One form of solar heating can be almost free: building a house so that the house itself is the collector.



Passive
South-facing windows collect the sunlight. Inside the windows is material that will hold heat, like concrete or drums of water.
The house is very well-insulated, perhaps with earth berming. There are few heat-losing windows on northern sides.

Ventilation is arranged to take advantage of prevailing winds and to exhaust the hottest air in summer.

Some Other Renewables

Plants can be grown to make fuels like firewood or alcohol. Such fuels may be very useful in rural areas. It seems unlikely they will ever be as cheap for city people as fossil fuels have been.

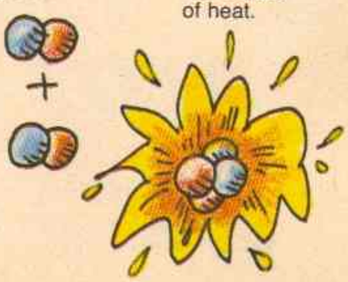
Photovoltaic cells change sunlight directly to electricity. Today they are cheap enough to compete with conventional generators in remote areas.

Windmills have been used for centuries. Now the government is experimenting with big wind-powered generators.

And Some Not-Quite-Renewable. . .

Geothermal energy provides 7% of San Francisco's electricity. Near there, the earth's heat makes very hot steam. Engineers are working out ways of using the heat from drier and cooler rock layers.

Fusion is the process that powers the sun; two small nuclei join to make a bigger one. Enormously high temperatures are needed. If we can figure out how to do this, we will have an enormous supply of heat.



sunlight . . . coal . . . oil . . .

You've learned about five of today's most important energy sources. Their names are listed above.

Answer the following questions on a separate piece of ruled paper, numbering your answers. The answers to some of the questions can be found in the pages you have just read. Unless your teacher tells you not to, you may turn back to those pages and look for the answers. The answers to the rest of the questions are not spelled out in what you have read, but you can arrive at the answers by thinking about what you have read.

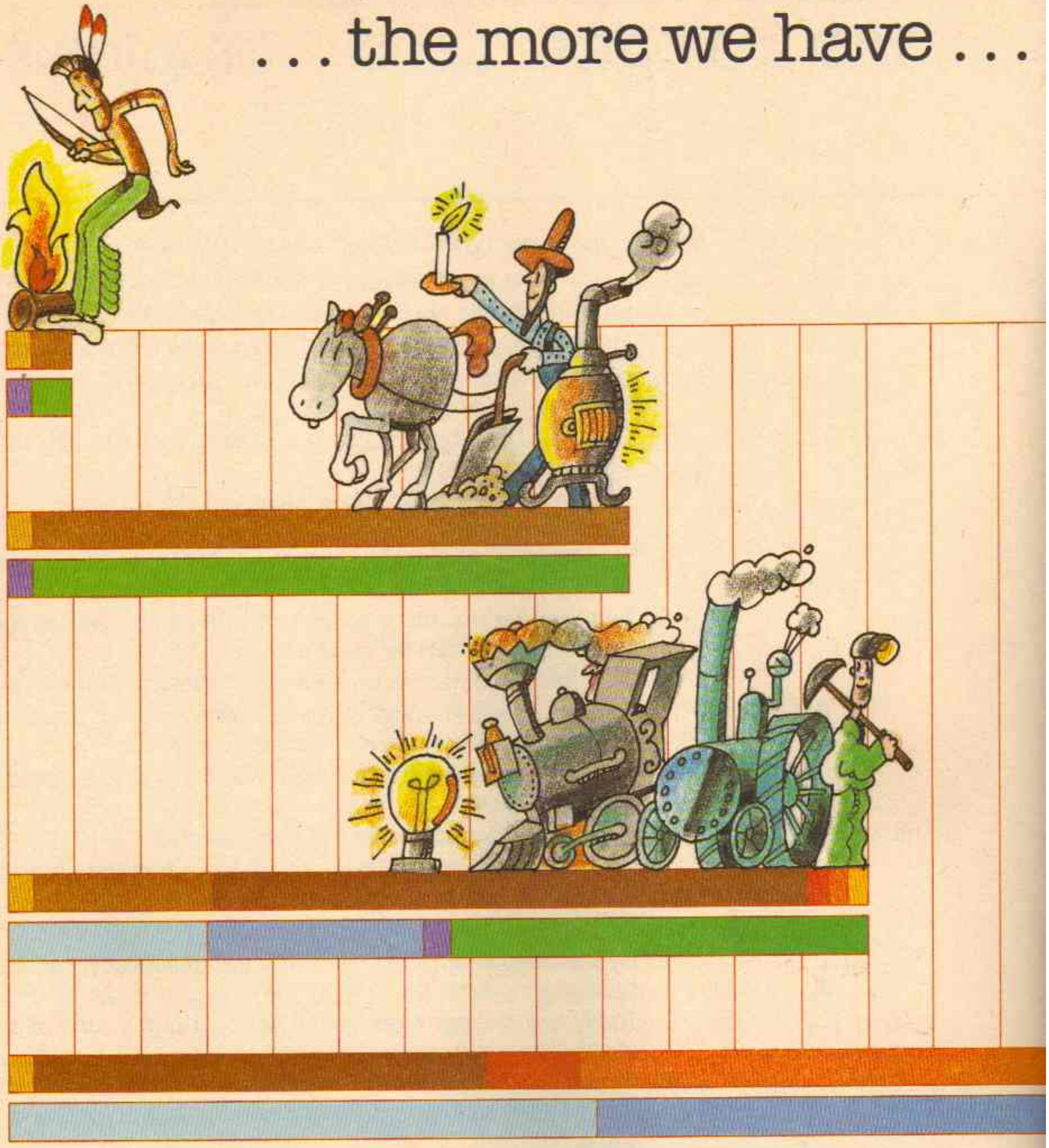
1. Which energy sources are called the "fossil fuels"?
2. Which source provides the energy we get from hydroelectric plants?
3. Which energy sources come from the sun?
4. Which energy sources are extracted from the ground?
5. Which energy sources can be used to generate electricity?
6. Which energy source provides the energy we get from firewood?
7. What is the biggest use for coal in the United States today?
8. Which source provides the energy we use to run our airplanes, trucks, and automobiles?
9. Which fossil fuel is most abundant in the United States?
10. Which energy sources can be transported by pipelines?
11. Which came first, widespread use of coal or widespread use of oil?
12. How is heat from a solar collector carried into a house?
13. What are the three main chemical elements in food?
14. Which chemical element is coal made of?
15. Which chemical element is used as fuel in commercial nuclear power reactors?
16. At about what date did wood stop being our chief energy source?
17. At about what date did coal stop being our chief energy source?
18. Name two problems that have kept us from using more coal than we do.
19. Which energy source is now used only to generate electricity?
20. How did coal and the railroads contribute to each other's development in the United States in the 1800s?
21. Why are some people concerned about the carbon dioxide produced when fossil fuels are burned?
22. Why were large amounts of oil sold decades before large amounts of gas?
23. Which energy source has been used to provide most of the iron and steel we use?
24. How does a solar heating system keep a home warm when the sun isn't shining?
25. In a nuclear power plant, energy is transformed from one form to another to another to another. Name the four forms of energy and tell which devices are used to perform each of the three transformations.

natural gas . . . nuclear fission

True or False?

1. In the West, coal is usually surface-mined.
2. Crude oil is a mixture of many different chemicals.
3. Studying fossils in rocks helps geologists locate oil.
4. In the early 1900s, the United States was the world's biggest oil exporter.
5. George Washington's inaugural ball was lit with the newly-invented kerosene lanterns.
6. Heat can be transferred from a solar collector to the rooms in a house simply by moving air.
7. Coal can be changed into a liquid fuel like gasoline.
8. Usually, a greater percentage of the coal will be recovered in a coal seam that is being surface-mined than will be recovered in a seam mined by underground mining.
9. In a breeder reactor, uranium that cannot be used as fuel is changed into a substance that can be used as fuel.
10. Only in the last ten years have people learned how to build solar collectors.
11. The first practical engines that converted heat to useful work were built at around the time of the American Revolution.
12. Some of the coal we burn today was living green plants before there were dinosaurs.
13. New deposits of coal are still being formed.
14. When oil stops flowing from an oil well, all of the oil in the ground beneath the well has been removed.
15. Most of the uranium mined is not useful as fuel.
16. By the beginning of the Civil War, the oil industry had become the biggest business in America.
17. Today, we can get more useful heat out of a pound of coal than people could a hundred years ago.
18. Someone could make a 50-horsepower electric automobile that would run on electricity from solar cells on the hood, roof, and trunk, without using batteries.
19. Water is needed for the formation of coal.
20. Many years ago, people were making gas and oil from coal.
21. Plastics made entirely from crude oil usually contain molecules that are not found in crude oil.
22. The sun's energy comes from a nuclear reaction.
23. A nuclear power plant could explode like an atomic bomb.
24. Nuclear power plants produce wastes that must be kept from the environment.
25. A well-designed house with a solar heating system will be very well insulated.

Energy . . . the more we have . . .



1700

An Iroquois Indian used the heat from burning wood to cook his food, to warm himself in winter, and even to make tools. But to drive his tools — hoes, scrapers, bows — he had to use his own muscle power. The things he needed he could gather in the forest. He didn't need to carry them far or change them much. Some people today live much as the Iroquois did in 1700.

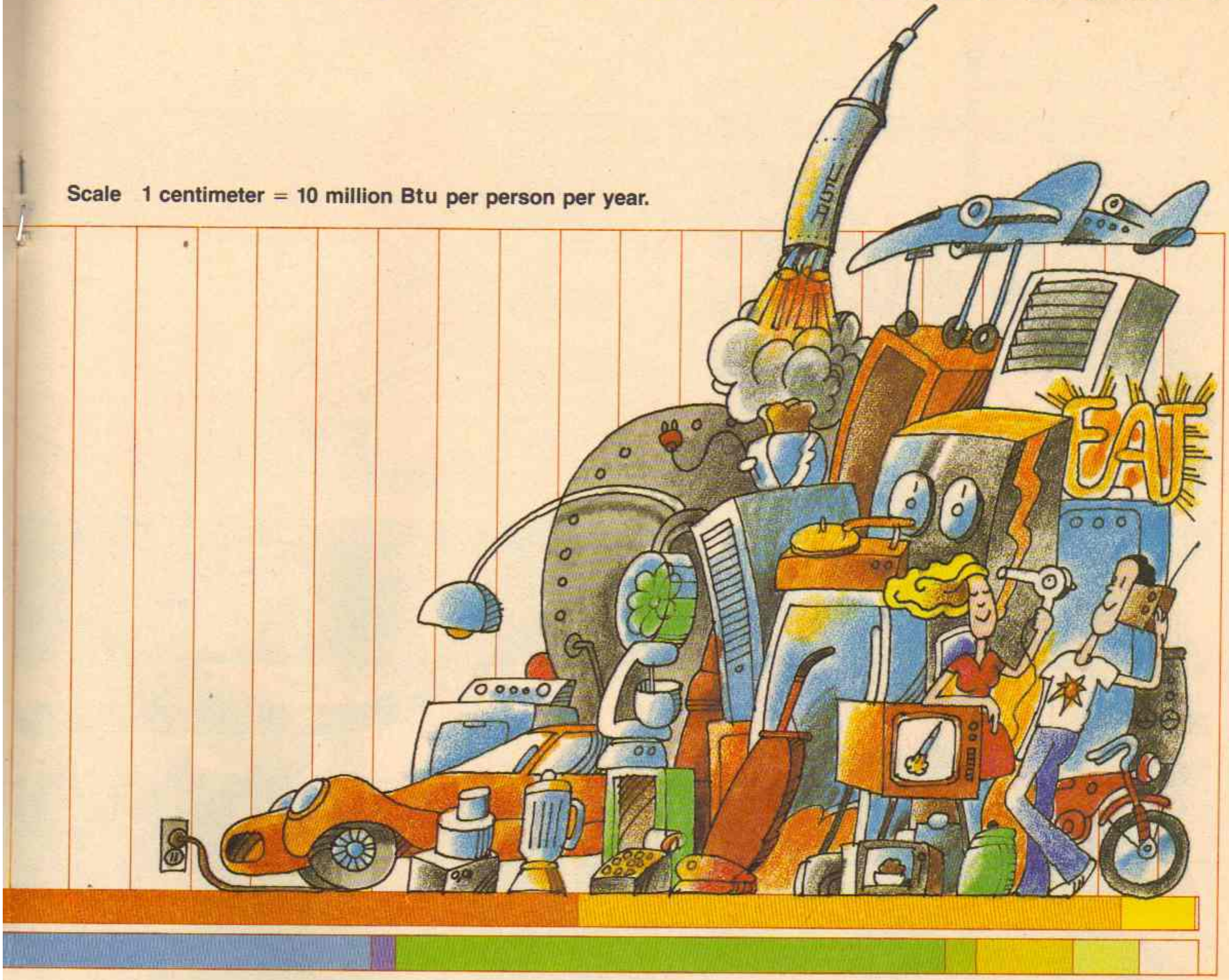
1800

The people of the new nation got almost all their energy from the same sources as the Iroquois did, but new ways of using energy were making their lives easier.

Firewood warmed their houses and shops and cooked their meals — but an iron Franklin Stove got a lot more useful heat from a log than an Indian campfire could get. Food energy produced muscle power, pulling plows for farming and wagons and carriages to transport goods and people. A human treadmill powered the first American factory, but a waterwheel soon replaced it. Factories that needed mechanical power would soon appear on waterfalls near big cities. Wind power moved ships across the oceans, and Americans had begun to mine coal for their iron industry.

the more we use . . . the more we want . . .

Scale **1 centimeter = 10 million Btu per person per year.**



1900

Life in America had changed a lot. Trains crossed the prairies to California, steamships traveled to Europe—and coal powered them both. Coal fed the boilers of factories and heated city homes. Coal-burning tractors were even taking the place of horses on farms.

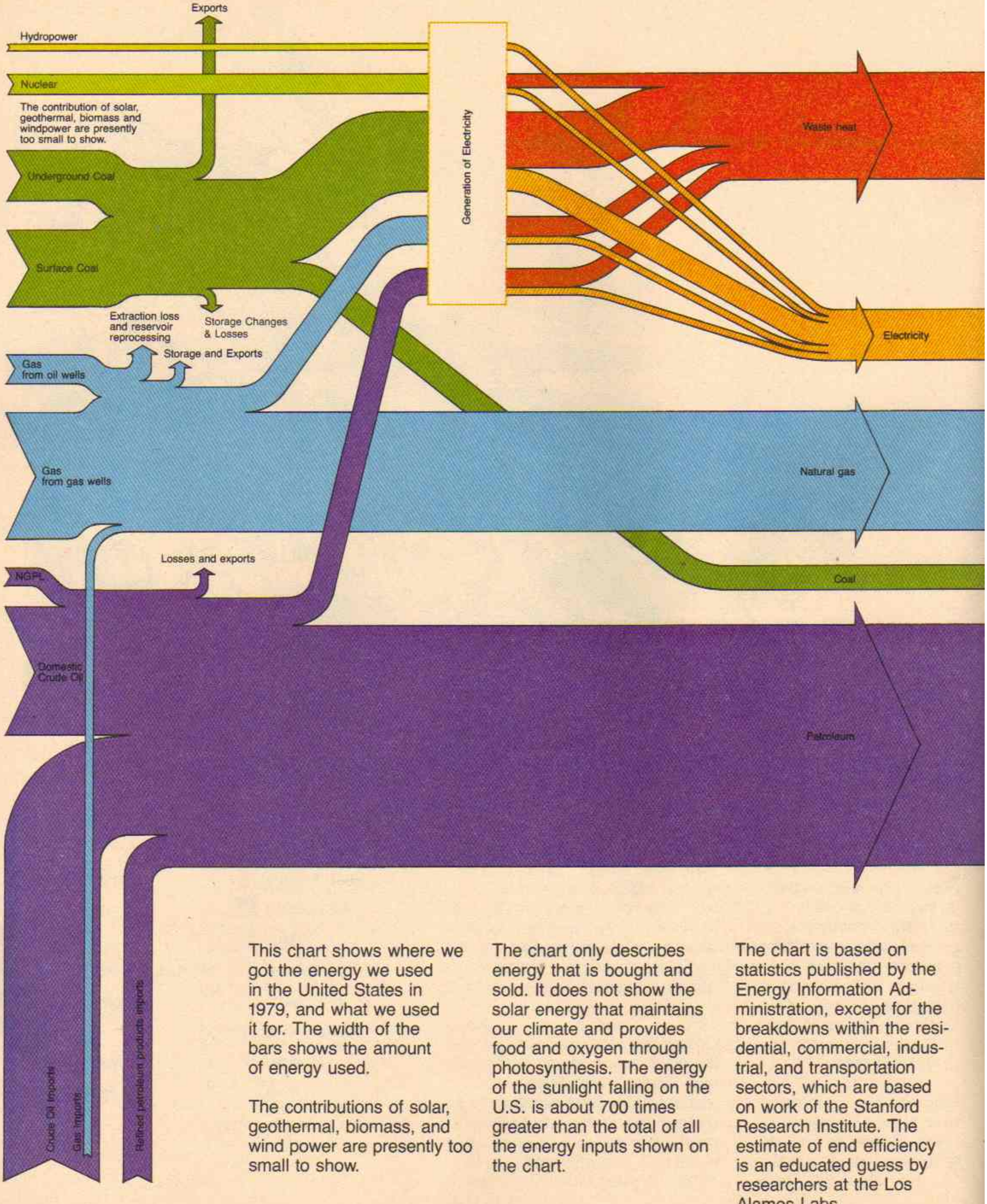
Coal was king! But there were signs of things to come. Oil and natural gas were being used for lighting (in a few large cities there were even electric lights—the electricity usually came from coal-fired generator stations). And a few thousand horseless carriages had been sold, with gasoline engines.

1979

Oil had replaced coal as the main source of energy. Transportation and manufacturing were using much more energy—but, most important, look at how much more energy each person is using today.

Sources		**Uses**	
Food Energy	🟧	Transportation	🟦
Firewood	🟫	Industry	🟦
Coal	🟫	Food	🟪
Hydropower	🟥	Homes, Offices, Stores	🟩
Petroleum	🟧	*Space Heating*	🟩
Natural Gas	🟧	*Cooking*	🟩
Nuclear	🟨	*Water Heating*	🟨
Other	☐	*Refrigeration*	🟨
		Other	☐

here it comes... Energy Production



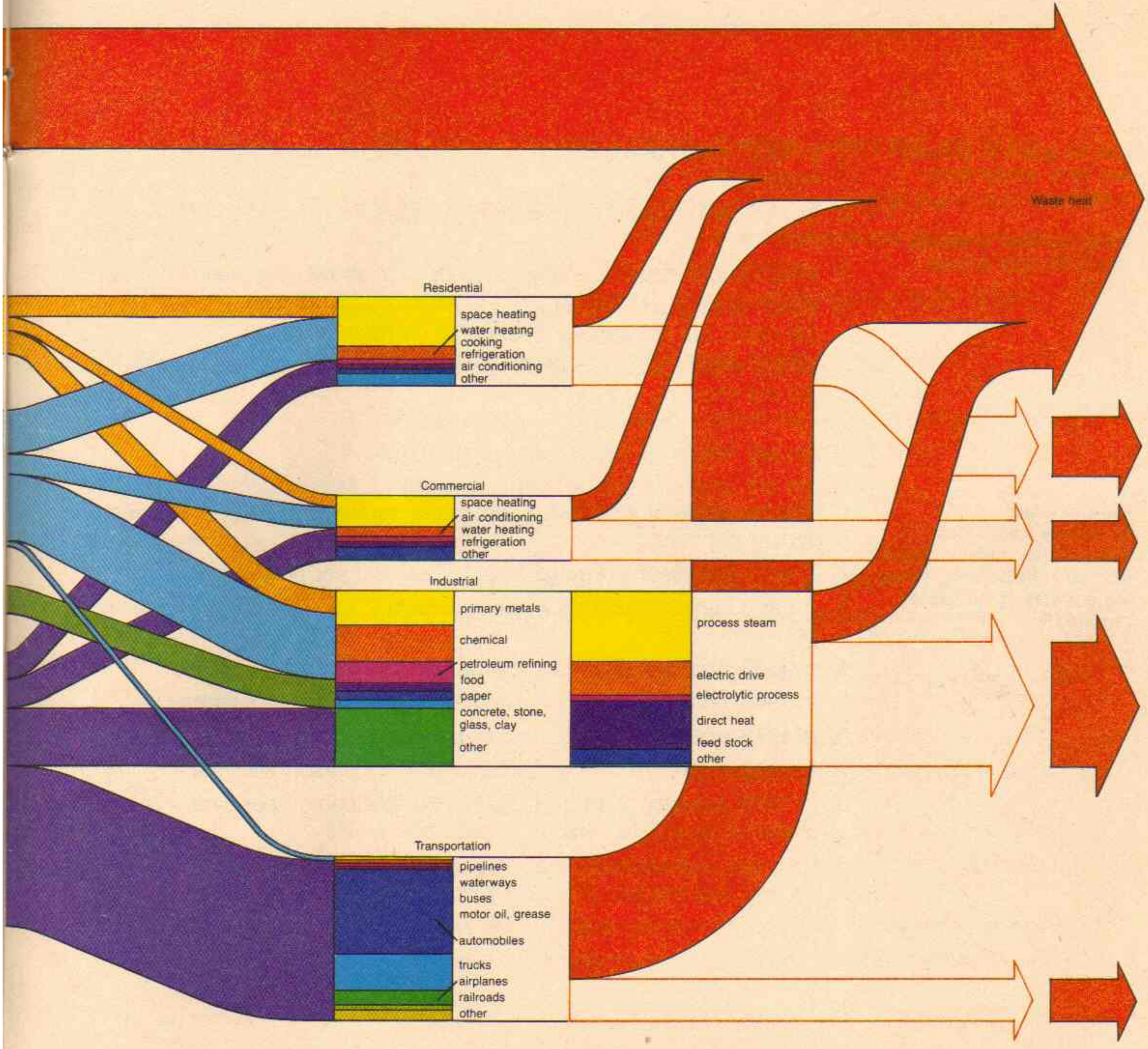
This chart shows where we got the energy we used in the United States in 1979, and what we used it for. The width of the bars shows the amount of energy used.

The contributions of solar, geothermal, biomass, and wind power are presently too small to show.

The chart only describes energy that is bought and sold. It does not show the solar energy that maintains our climate and provides food and oxygen through photosynthesis. The energy of the sunlight falling on the U.S. is about 700 times greater than the total of all the energy inputs shown on the chart.

The chart is based on statistics published by the Energy Information Administration, except for the breakdowns within the residential, commercial, industrial, and transportation sectors, which are based on work of the Stanford Research Institute. The estimate of end efficiency is an educated guess by researchers at the Los Alamos Labs.

& Consumption... there it goes



Scale 1 mm = 0.7 quadrillion Btu

Working with the Energy Graphs

Use the graph on pages 24 and 25 to answer these questions.

Circle the word or phrase that is the right answer.

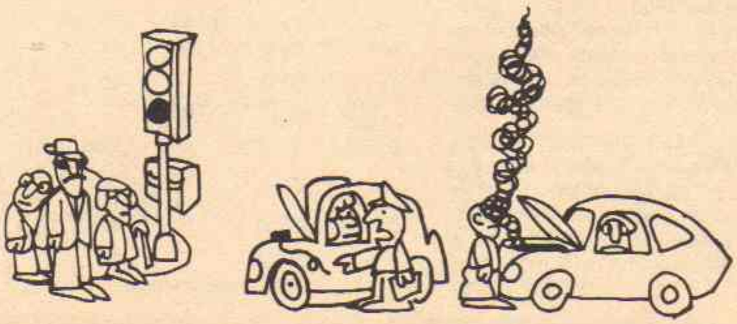
1. In 1900, which used more energy per person, TRANSPORTATION or INDUSTRY?
2. In 1979, which used more energy per person, TRANSPORTATION or INDUSTRY?
3. Which supplied more energy in 1900, HYDROPOWER or WOOD?
4. Which energy sources supplied enough energy in 1900 to show up in the chart, but not enough to show up in 1800?
5. Which energy sources were important enough to show up in 1979 but did not show up in 1900?

Using a Scale
To answer these questions, you will need a ruler marked in millimeters. Write the answers in the spaces provided.

1. Find the scale. It says that 1 centimeter equals __________ Btu per person per year.
2. Then 1 millimeter will equal __________ Btu per person per year.
3. A bar 3 centimeters long would represent __________ Btu per person per year.
4. In 1800, coal supplied __________ Btu per person per year.
5. In 1900, coal supplied __________ Btu per person per year.
6. In 1979, coal supplied __________ Btu per person per year.
7. In 1900, industry used __________ Btu per person per year.
8. In 1979, industry used __________ Btu per person per year.

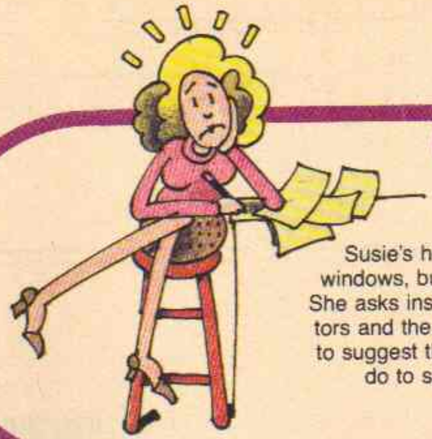
Answer these questions after you have studied the energy flow diagram on pages 26 and 27. Write your answers on a separate piece of ruled paper, numbering your answers. You may want to use a ruler to compare the widths of arrows.

1. This diagram provides a picture of energy supply and use in the United States in what year?
2. What is the largest single source of energy used in the United States?
3. What was the largest single source of domestically produced energy (that is, not counting imported energy)?
4. What were the three largest sources of the energy used to generate electricity?
5. What energy source provided most of the energy used in transportation?
6. What energy source provided most of the energy used in homes?
7. What form of energy did we export the most of?
8. What form of energy did we import the most of?
9. What was the largest single use for coal?
10. Of the four sectors shown, Residential, Commercial, Industrial, and Transportation, which used the most natural gas?
11. Which provided more energy, coal mined underground or surface-mined coal?
12. Did we get more natural gas from oil wells or from wells specifically drilled for gas?
13. Which used more natural gas, homes or industry?
14. Of the industrial uses of energy, which two used the most energy (not counting "other")?
15. Which used more energy, homes (residential) or transportation?
16. Of the energy uses in residences, except "other," which two used the most energy? (List the biggest use first.)
17. What was the largest single use of energy in the commercial sector?
18. Which used more energy, running automobiles or heating homes?



Investing in Energy

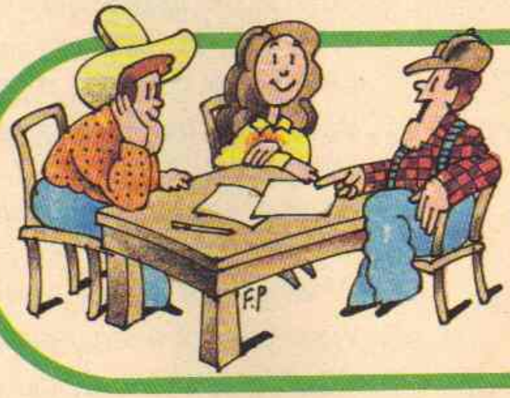
Susie Homeowner's energy bills are going up. What can she do about it?



①

Susie's house has storm windows, but no insulation. She asks insulation contractors and the utility company to suggest things she could do to save energy and money.

Jack, Jane & Jim Investor, who live in a small Rocky Mountain town, have saved $50,000. They would like to use their savings to make more money.



①

To do that they have to find something people need and will buy. Energy is something people in their town need. Could they sell energy?

Money Out

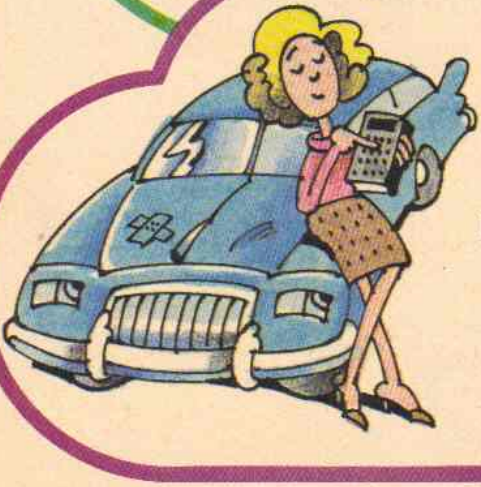
⑤

Every investment has some risks. The forest could burn down. A freak storm could destroy the windmill. The greater the risk seems to be, the greater the return needed to attract a rational investor like you.

All ways of getting energy cost something. There is only so much money with which to do things, so we have to decide what to do first. One way of deciding what to do is to choose those projects that will return the most money for each dollar spent.

If you were one of the investors, what would you choose to invest the $50,000 in?

possibility	left after 25 years
firewood	$362,668
wind generator	$528,290
bank account	$466,754



⑧

For the crawl space, Susie discovers that at the end of five years she would have $79 less than the $308 she'd get by leaving the $200 in the bank. Susie decides to insulate her attic, but not the crawl space. Instead, she is figuring out whether it would pay to trade in her old car for one that uses less gas.

Some ways of saving energy are free, but we often have to spend money to save energy. We get the money invested back in savings on energy bills. The smart thing is to do first the things that will save the most money per dollar invested.

year	money saved by end of year	interest earned at 9%	year-end cash
1	$153 + $113 tax credit	$0	$266
2	$168	$24	$458
3	$185	$41	$684
4	$204	$62	$950
5	$224 + $500 resale value	$86	$1760

②

things to do	price	annual saving
caulking and weatherstripping	$100 (do-it-herself)	$117
insulate attic	$750	$153
insulate crawl space	$200	$26

How much Susie saves each year depends on the price Susie has to pay for energy. She expects to keep her house five more years, and thinks the price of energy will rise 10% per year during those years. If so, an insulated attic would save Susie $224 in the fifth year, and an insulated crawl space $38.

③

It looks pretty obvious that weatherstripping and caulking would be a good thing to do. In the first year she will get back all she spent and $17 more. After that, she will save at least $117 a year until the caulking wears out.

But it isn't so clear whether Susie should spend the $750 for the attic or the $200 on the crawlspace. Susie needs to find out what her costs and savings would be during the five more years she expects to keep the house.

④

Susie has saved money that is earning 9% interest each year. If she leaves the $750 in the bank, at the end of five years she will have $1155, and $308 if she leaves the $200 the crawl space would cost. On the other hand, if she could lower her energy bills, she could save the extra money and earn interest on it.

⑤

Susie calls a friend who is a real estate agent. He says he thinks that buyers five years from now might pay $500 more for her house if the attic was insulated, but they might not realize insulation in the crawl space was valuable.

⑥

Susie will also save some taxes. Congress allows you to deduct 15% of the first $2000 you spend on insulation from your income tax.
$750 × 15% = $113;
$200 × 15% = $30

⑦

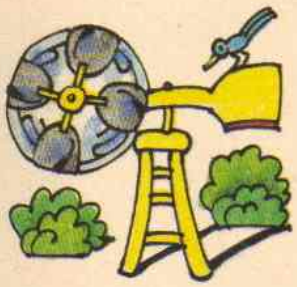
Susie takes $750 out of the bank and insulates the attic. In five years she will have $1760 instead of the $1155 she would have if she left the money in the bank. She will be $605 ahead!

Money In

②

They could set up a firewood business. They could buy 100 acres of wooded land for $40,000. For $10,000 more they could get a truck and equipment to cut and haul the wood. If they cut only as much wood as grows each year, they would get 100 cords per year, which could be sold for $16,000 a year. But they would have to pay for gasoline, truck, and saw maintenance, and the wood-cutter's wages, which they estimate would total $15,000. They think the value of the land, the price of wood, and wages and other costs will go up about 7% a year. They figure out that if they did this, banking earnings at 9%, at the end of 25 years the value of the land and the profits would be $362,668.

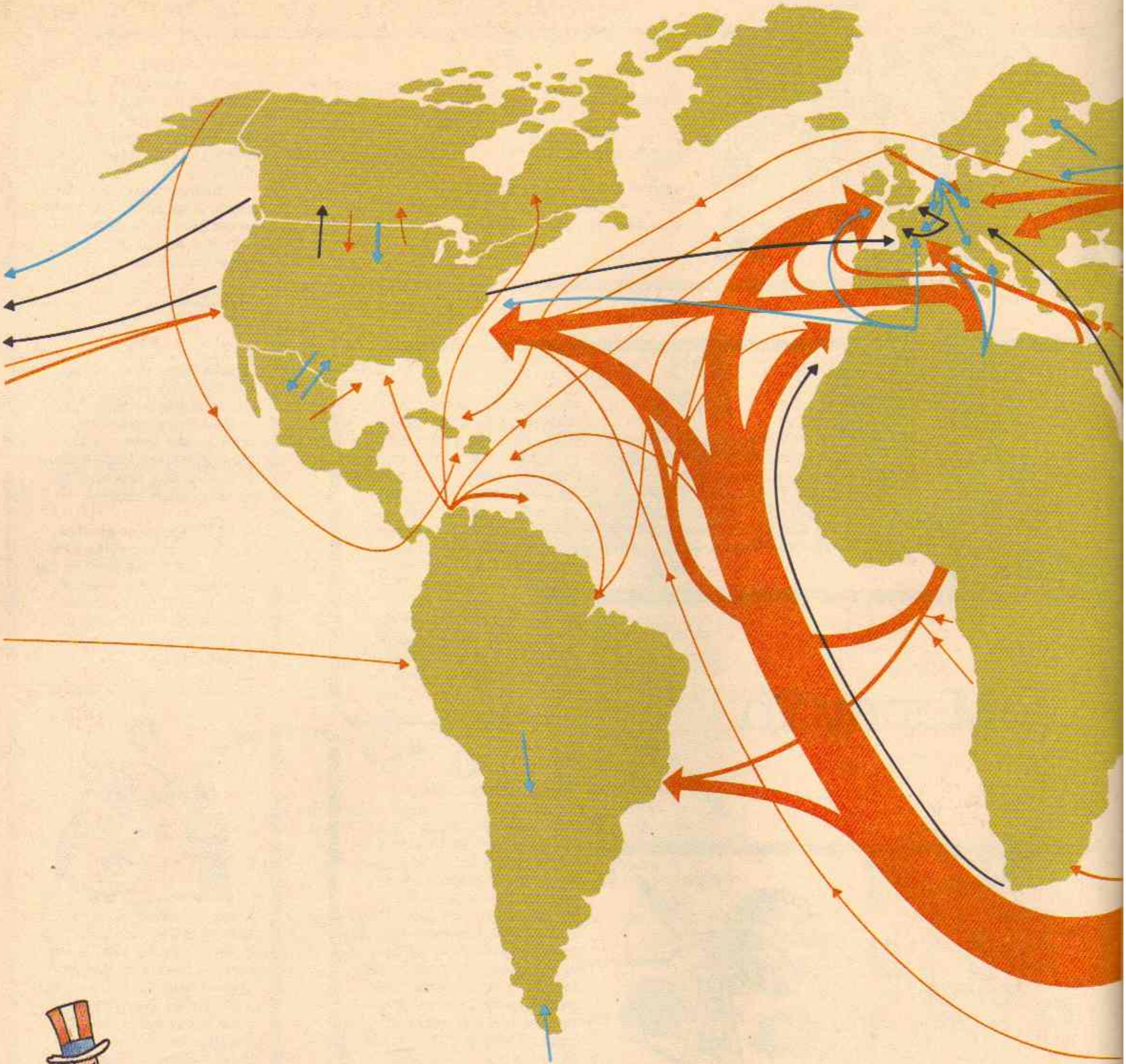
③



They could buy a wind generator for $37,800 plus $12,200 for shipping, land, and installation. At 7¢ a kWh, they could get $3500 for the electricity generated the first year, and maintenance the first year would cost $200. They think this cost and the selling price of the electricity will go up 7% a year. They can invest earnings at 9%. The machine should last for 25 years, and then the land and machine could be sold for $1000. At the end of 25 years, they would have $528,290.

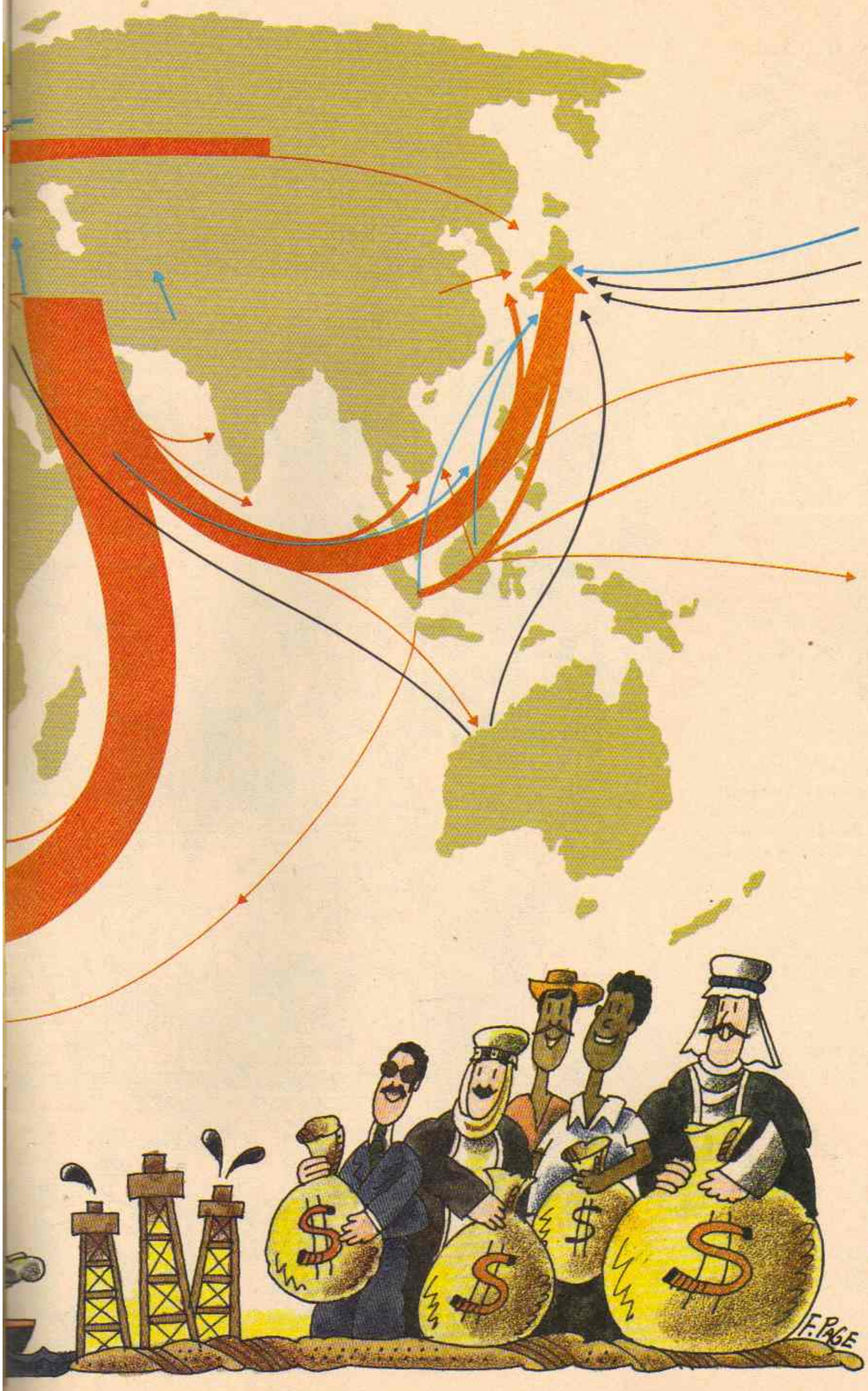
④

Or they could put their money in certificates of deposit in the bank, where it would earn 9% interest. If they did this, at the end of 25 years they would have $466,754.



GAS
GAS
GAS
GAS
OIL
OIL
OIL

Buying energy abroad



Oil is by far the biggest item in world trade, in both bulk and value. The United States buys the most. In 1981, our chief suppliers were Saudi Arabia (19%), Nigeria (10%), and Mexico (9%). We also buy refined products from other nations that began as crude oil from those nations.

In 1981, we bought about 76 billion dollars worth of oil from other countries. Seventy-six billion dollars is about the value of everything GE, U.S. Steel, Xerox, Ford and Kodak own. It is 90% of the entire 1981 net income of the 500 largest industrial companies in America.

Cost alone does not tell the whole story. In 1978 Germany and Japan together bought about as much oil as we did. They have no oil fields in their countries. But they sold more goods to other countries than they bought. We did not succeed in doing that, and that made the dollar worth less.

Finally, it is a long way to the Middle East and Africa. If there were ever another war like World War II, it would be almost impossible to prevent the sudden loss of half our supply of liquid fuels. And, of course, our suppliers could turn off the oil, as many did in 1973.

🟧 **Oil**
■ **Coal**
🟦 **Natural gas**

Energy Trade between Nations in 1979. Arrow width is proportional to volume of trade for flows equivalent to more than 400,000 barrels of oil per day.

Saving Energy Dollars

If your family's like most, you could really lower your home energy bills. Some people have cut theirs in half! You don't have to freeze in the dark to do it, either. Most of the energy dollars spent at home are spent just to move heat around. The more control you get over the moving heat in your house, the lower your bills can be.

Saving Energy Through Smart Buying

Today, you have a choice of different brands and models for almost anything you want to buy. When your family is shopping for an appliance, one of the things you ought to think about is how much energy the appliance will use. The right choice can save a lot of money. For example, in some areas you will pay more for the electricity some refrigerator models use during their lifetimes than you paid for the refrigerator.

How can you find out how efficient a model is? Most major appliances have labels comparing the energy-efficiency of that model with similar models (a lot like the EPA mileage rating on a car). Some utilities and consumer agencies give out lists of energy-efficient models. Your local public library can also provide consumer information.

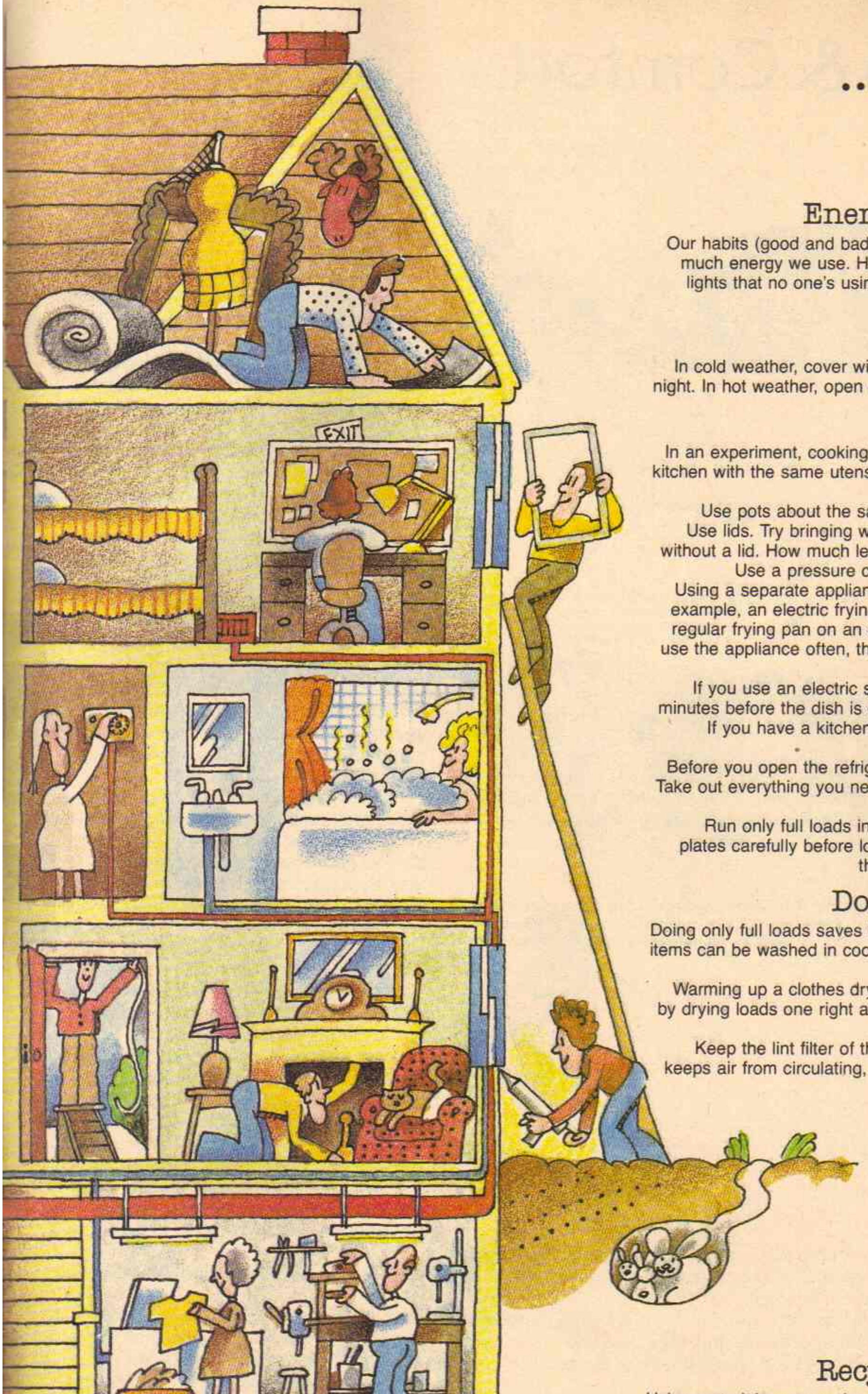
Some new appliances use much less energy than older models. Kitchen ranges can now be bought with automatic electronic ignition instead of pilot lights (pilot lights use as much as 30% of all the gas a range uses). Better insulated gas and oil water heaters are available, with flues that transfer more of the heat from the flame to the water. Added features like these often add to the purchase price. But it may be smart to pay more now to avoid paying even more for energy later on.

Indirect Energy Costs

It takes energy to make and carry to us everything we buy, big and small. In fact, it takes more energy to make some appliances than the appliance consumes during its whole lifetime. Each year, the average family buys about two-thirds as much energy indirectly as it buys in the form of gas, oil, and electricity.

Buying things that will last a long time and can be repaired if they break is an excellent way of saving energy.

... at home



Energy-smart Habits

Our habits (good and bad) make a big difference in how much energy we use. How about you? Do you turn off lights that no one's using? . . . turn off the TV or radio when you leave?

At Bedtime

In cold weather, cover windows by pulling the drapes at night. In hot weather, open windows to let in cool night air.

In the Kitchen

In an experiment, cooking the same recipes in the same kitchen with the same utensils, some cooks used twice as much energy as others!

Use pots about the same diameter as your burners.

Use lids. Try bringing water to a boil in a pot with and without a lid. How much less time does it take with a lid?

Use a pressure cooker instead of a regular pot.

Using a separate appliance can often save energy. For example, an electric frying pan uses less energy than a regular frying pan on an electric burner. But if you don't use the appliance often, the energy used to manufacture it is wasted.

If you use an electric stove, turn the burner off a few minutes before the dish is done; it'll coast to a stop itself.

If you have a kitchen exhaust fan, use it during hot weather.

Before you open the refrigerator, decide what you need. Take out everything you need for a meal, all at once, and quickly.

Run only full loads in the dishwasher. If you scrape plates carefully before loading, you don't need to rinse them. (That uses up hot water!)

Doing the Laundry

Doing only full loads saves hot water and electricity. Many items can be washed in cool water, and almost everything can be rinsed in cold water.

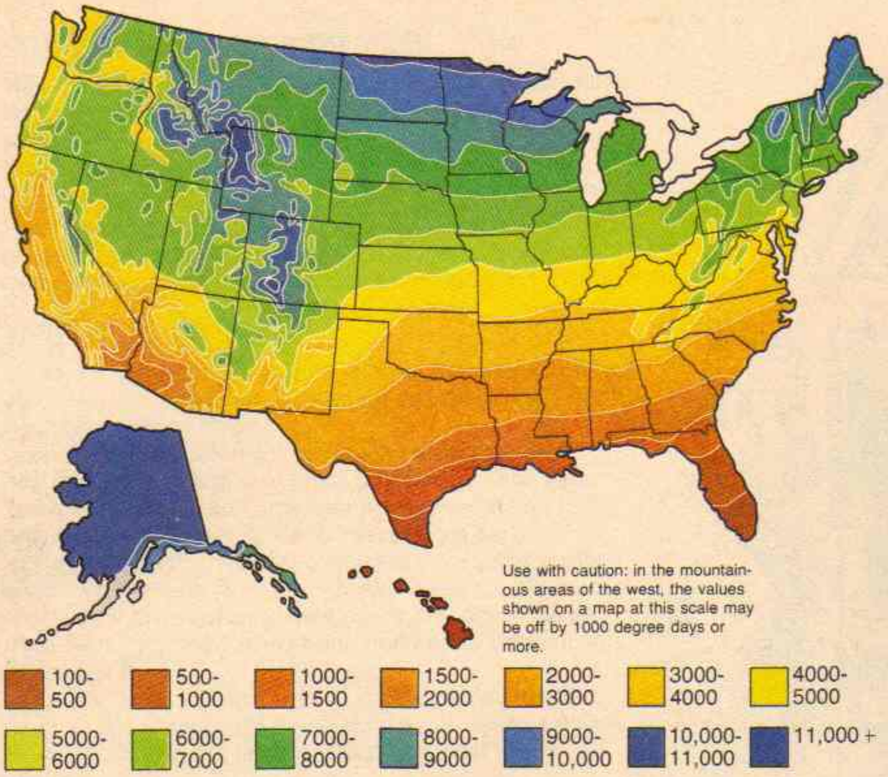
Warming up a clothes dryer takes energy. Save energy by drying loads one right after another, without giving the dryer a chance to cool off.

Keep the lint filter of the dryer clean. A clogged filter keeps air from circulating, and that means the dryer has to run longer to dry a load.

Recycling Materials

Using materials over again can save energy. For example, it takes about 20 times more energy to get aluminum from ore than from used cans.

Climate & Comfort



Use with caution: in the mountainous areas of the west, the values shown on a map at this scale may be off by 1000 degree days or more.

Annual Heating Degree Days

A map like this can give only a rough idea of the average climate over large areas. For example, within an area, sites on a mountaintop would be colder than average, while those on a south-facing slope would be warmer. Find the place where you live. How many heating degree days are needed in your climate? ____________ degree days

Describe your climate. Describe each month by placing a check in one of the rows from cold to hot. If the month is especially sunny, check the sunny box; in the last row write W or C if the month is particularly Windy or Calm. In the last column, enter the total number of checks in each row.

	J	F	M	A	M	J	J	A	S	O	N	D	T
Cold													
Cool													
Comfortable													
Warm													
Hot													
Is it sunny?													
W for windy; C for calm													

For each climate, there are special ways of designing a house that can keep us comfortable. A house that would be perfect in one climate could be a big energy waster in another.

Some climates are too cold at night, too hot in the day: lots of heavy stone or adobe inside the house can store the night coolness.

Hot *and* dry, like Arizona? Instead of air conditioning, evaporative cooling can be used.

Cold and sunny, like Colorado? Perfect for passive solar space heating.

How much heat do people need where you live? If the outside temperature is 65°F, you can get all the heat you need from lights, appliances, and your own body heat. You don't need to buy extra heat. But when the outside temperature goes below 65°F, people start to buy heat. The colder it gets, the more heat they buy. Engineers use a unit called the **heating degree day** to estimate how much heat the weather will make people buy.

The map to the left shows annual heating degree days, averaged over thirty years. (Some years are colder than others.) If one place has twice as many heating degree days as another, it will take about twice as much energy to keep warm there.

Compare the climate where you live with other climates in the United States. Do you think your home uses more or less energy to provide heat than the average American home? (Circle one.)

MORE ENERGY   AVERAGE   LESS ENERGY

Do you think your home uses more or less energy for air conditioning than the average American home?

MORE ENERGY   AVERAGE   LESS ENERGY

Turn to page 27 and look at the bar marked "Residential." The yellow part of the bar shows what part of the energy consumed in American homes is used for space heating. About how much of all the energy used in homes went to provide space heating?

ONE-TENTH   ONE-HALF   THREE-QUARTERS

How much of the energy used was for air-conditioning?

ONE-TENTH   ONE-HALF   THREE-QUARTERS

Probably nobody's house uses energy in exactly the same proportions as the averages in the graph. Almost half the homes use no energy for air conditioning. A home in southern Florida might use no energy for heating, but a lot for air conditioning.

Climate is one factor we need to consider in deciding how much to spend on conservation measures like insulation. People in Minnesota buy much more heat than people in Florida do, and so insulating can save them more money than it saves Floridians (ignoring air conditioning).

The **cost of energy** is the second factor to consider. The more you are paying for a therm of gas or a gallon of fuel oil the more money you can save by insulating.

And lastly, we need to consider the **cost of insulation.** The more expensive insulation is, the less you can save by insulating.

Here is a way to estimate what conservation measures are worthwhile in your climate, at the price you pay for energy.

First, find out how much you pay for the energy you use to heat your home. Check your family bills, or call the utility company. Don't use the average cost. Use the cost of the last unit of energy you bought (because that is the unit that will be saved).

Second, find your location on this map. In what heating zone is your home? If you are on the border between two zones, or if the climate your house is in is not typical of the area, choose the zone whose weather seems closest to the weather you have.

Third, use the table to find the number of heating points for your location and the price you pay for energy.

Air Conditioning

If you use air conditioning in your home, find your home on the red map. Then use the red table to find your recommended cooling points. For cooling, we need two different kinds of points. The number above the line is cooling points for the attic ($\frac{2}{\ }$); the number below the line is cooling points for walls ($\frac{\ }{1}$).

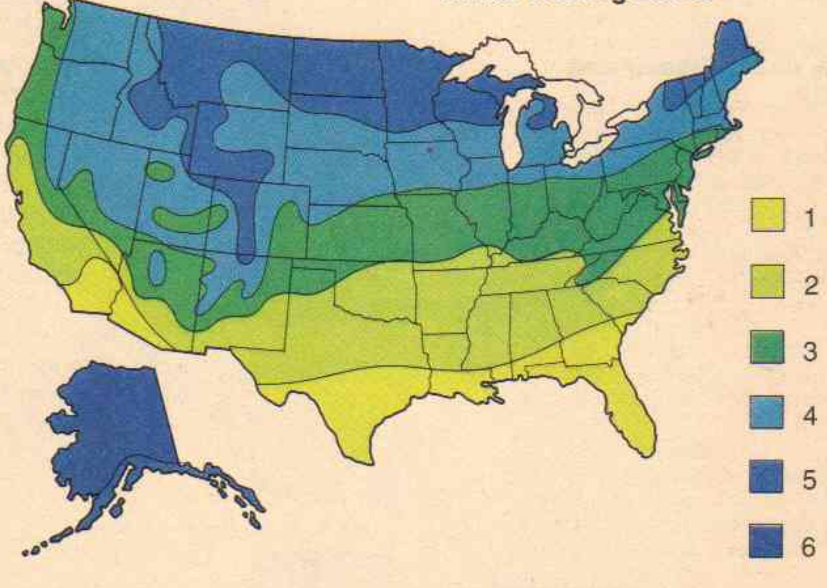
Now add up the points for your climate:

Heating points ____________
plus attic cooling points + ____________
equals total attic points ____________

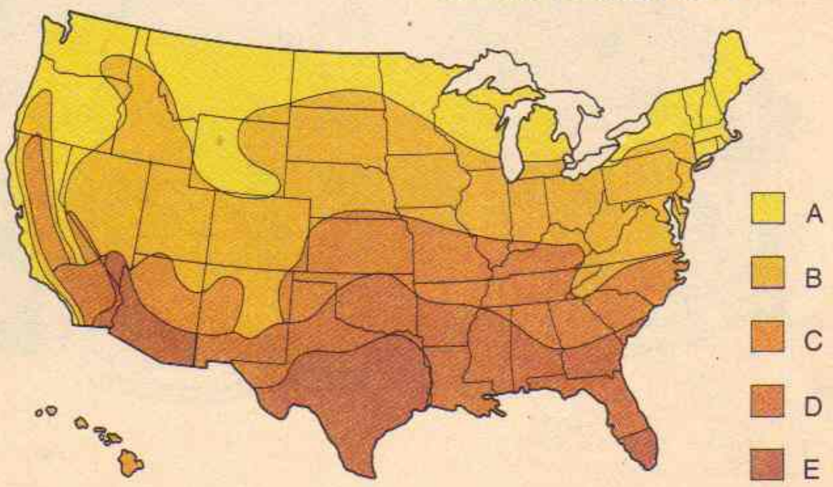
Heating points ____________
plus wall cooling points + ____________
equals total wall points ____________

Energy Source	**Cost of energy**															
Gas (cents/therm)	9	12	15	18	24	30	36	54	72	90	126	162	216	270	360	450
Oil (cents/gallon)	13	17	21	25	34	42	50	75	100	125	175	225	300	375	500	625
Electricity (cents/kWh)					1	1.3	1.6	2	3	4	5	7	9	12	15	20	25
Electric heat pump					2	2.6	3.3	4	6	8	10	14	18	24	30	40	50
Heating zone																
1	1	1	2	2	2	3	3	5	6	8	11	14	18	23	30	38
2	3	3	4	5	6	8	9	14	18	23	32	41	54	68	90	113
3	4	5	7	8	10	13	15	23	30	38	53	68	90	113	150	188
4	6	7	9	11	14	17	21	32	42	53	74	95	126	168	210	263
5	7	9	12	14	18	23	27	41	54	68	95	122	162	203	270	338
6	11	14	18	21	28	35	42	63	84	105	147	189	252	315	420	525
Cooling zone																
A	0	0	0	0	0	0	0	data not available								
B	$\frac{1}{0}$	$\frac{1}{1}$	$\frac{2}{1}$	$\frac{2}{1}$	$\frac{2}{1}$	$\frac{3}{2}$	$\frac{4}{2}$	$\frac{5}{3}$	$\frac{7}{4}$	$\frac{9}{5}$	$\frac{13}{6}$	$\frac{16}{8}$	$\frac{22}{11}$	$\frac{27}{14}$	$\frac{36}{18}$	$\frac{45}{23}$
C	$\frac{2}{1}$	$\frac{2}{1}$	$\frac{3}{2}$	$\frac{3}{2}$	$\frac{4}{2}$	$\frac{6}{3}$	$\frac{7}{4}$	$\frac{10}{5}$	$\frac{13}{7}$	$\frac{17}{9}$	$\frac{23}{13}$	$\frac{30}{16}$	$\frac{40}{22}$	$\frac{50}{27}$	$\frac{67}{36}$	$\frac{84}{45}$
D	$\frac{2}{1}$	$\frac{3}{2}$	$\frac{4}{2}$	$\frac{5}{3}$	$\frac{6}{3}$	$\frac{8}{4}$	$\frac{9}{5}$	$\frac{14}{8}$	$\frac{18}{10}$	$\frac{23}{13}$	$\frac{32}{18}$	$\frac{41}{23}$	$\frac{54}{30}$	$\frac{68}{38}$	$\frac{90}{50}$	$\frac{113}{63}$
E	$\frac{4}{2}$	$\frac{5}{3}$	$\frac{6}{3}$	$\frac{7}{4}$	$\frac{9}{5}$	$\frac{11}{6}$	$\frac{14}{8}$	$\frac{20}{11}$	$\frac{27}{15}$	$\frac{34}{19}$	$\frac{47}{26}$	$\frac{61}{34}$	$\frac{81}{45}$	$\frac{101}{107}$	$\frac{135}{126}$	$\frac{169}{95}$

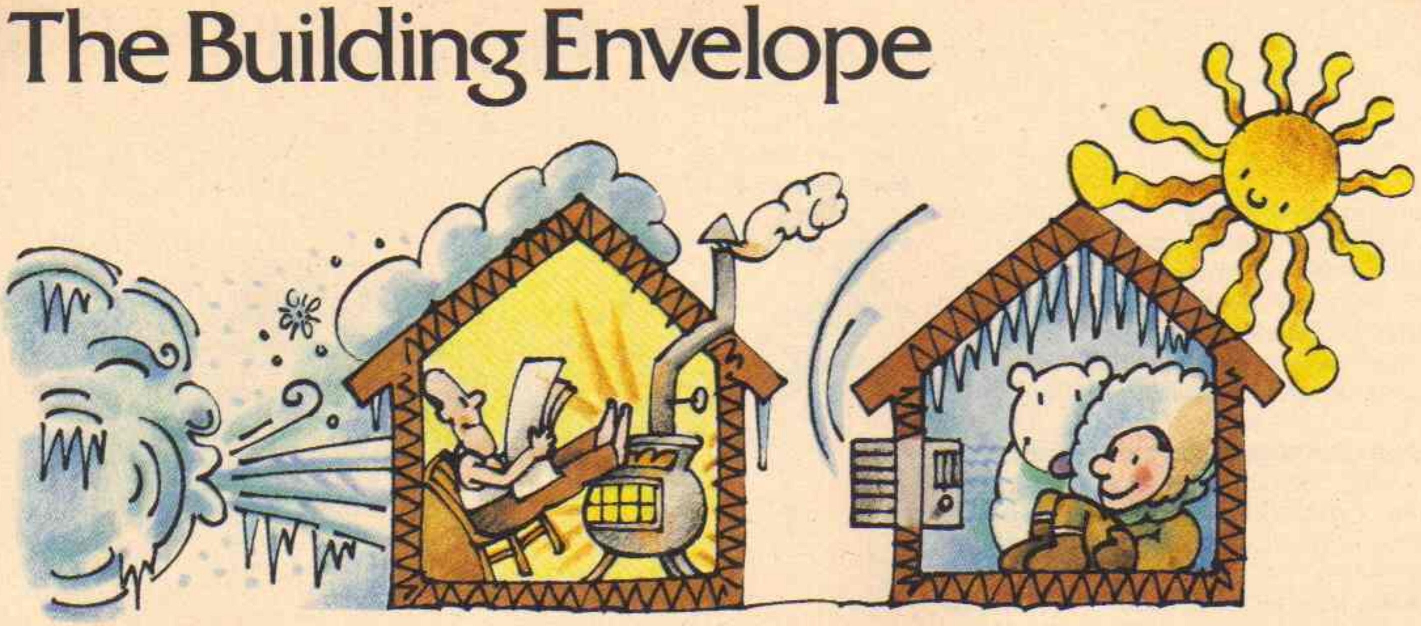
Winter Heating Zones



Summer Cooling Zones



The Building Envelope



The purpose of a building is to make a difference between outside and inside. Sometimes that means keeping heat in — and sometimes it means keeping heat out.

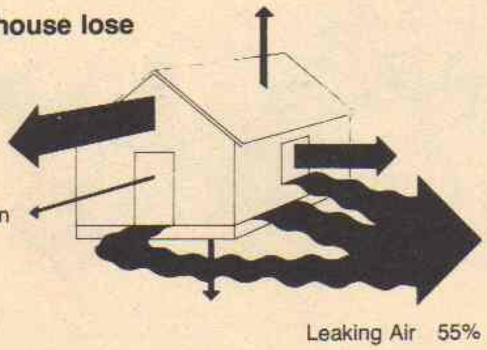
Underline the things you want to keep out of your home. Circle the things you want to let in. Put a question mark above things you sometimes want to keep out, but sometimes want to let in.

mice rain sunlight burglars air

heat snow pigeons mosquitoes

dirt people flies your cat wind

How does a house lose heat?

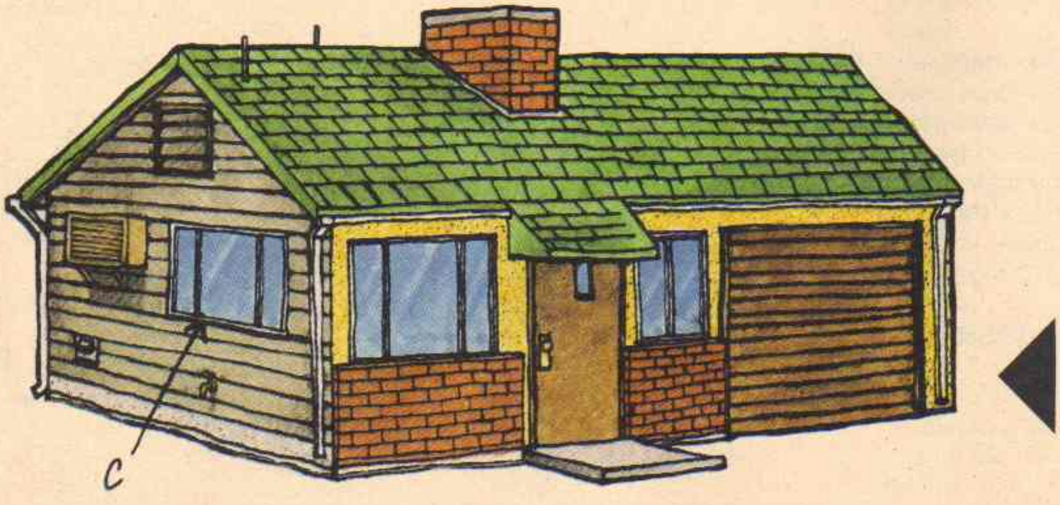


This is how one house near Washington, D.C., lost heat. Other houses lose heat differently, depending on the climate, the time of year, the way they were built and insulated, even the way the people in them live.

Most winter heat loss is through the roof, but most summer heat gain is through the walls.

Almost all buildings let air leak in (or out) of them. This changing of the air is called **infiltration.**

Infiltration is the first thing many people fix. Heating air is expensive, so not losing your heated air can save a lot of money. Stopping the leaks is one of the easiest and cheapest ways of saving energy, and anyway, drafts are annoying.



The outside of your home is made of many separate pieces of material. Air can leak through the cracks where those pieces join. At some of the cracks, the material on one side is supposed to move. At other cracks neither side is supposed to move.

Draw an arrow to each place in this house where two pieces of material meet, where there might be a crack. Label the arrow C if both sides are fixed, W if one side is supposed to move. An example is done for you.

& the Great Leak Hunt

Weather Stripping

Cracks where one side is meant to move are sealed with weather stripping. There are many different kinds of weather stripping. Metal strips on doors can last as long as the house. Foam or felt stripping needs to be replaced every few years.

Check the weather stripping on your home. Close the window or door on a dollar bill. Pull the bill out. If you feel resistance, the weather stripping is good. Try each door or window in several places.

condition of weather stripping

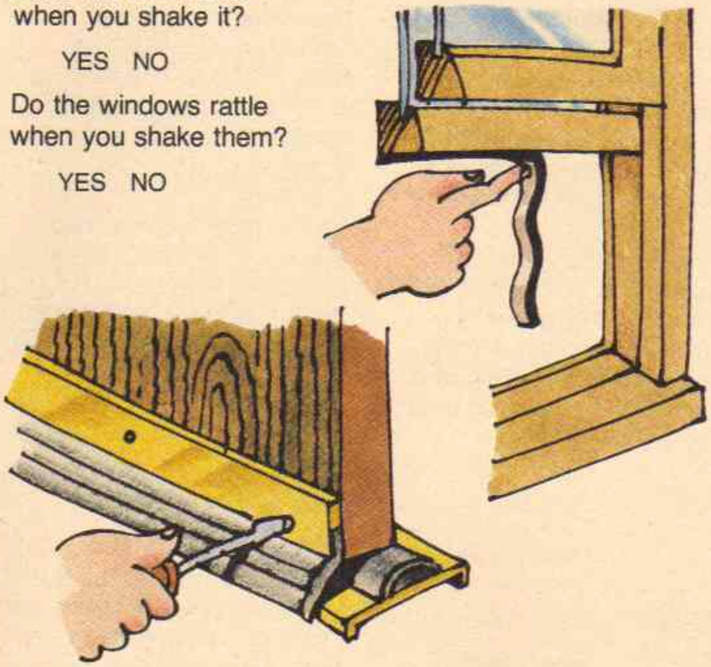
	good	not so good
front door		
back door		
windows		

How is the fit on your doors and windows? Does the door rattle when you shake it?

YES NO

Do the windows rattle when you shake them?

YES NO

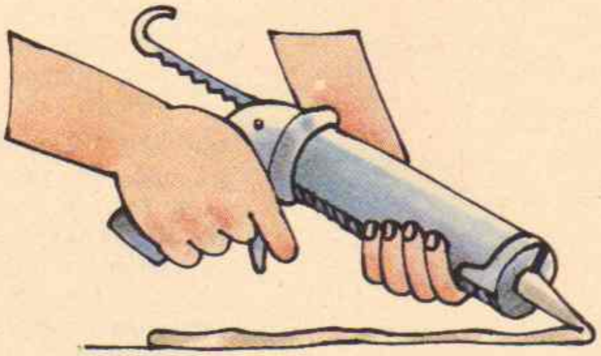


Caulking

Cracks where neither side is supposed to move are sealed with a material called caulking. Most caulking comes in cartridges. The cartridges fit in an inexpensive "gun" that squeezes the caulking out a nozzle, like toothpaste from a tube. Caulking your home can be a do-it-yourself job.

Caulking doesn't last forever. There are many kinds of caulk. Some last only one or two years. Some last more than ten years.

Check the cracks in your home that could be sealed with caulking. How good is the caulking?



Excellent condition: perhaps a few cracks, no pieces missing.
Good condition: some cracks, perhaps some pieces missing.
Poor condition: no caulking.

	condition of caulking		
	excellent	good	poor
Corners on the outside of the building			
Around exterior chimneys			
Around windows			
Around door frame			
Where pipes or wires enter the building			
Where dryer vents enter the building			
Between foundation and the sill plate			
Putty on windows			
Cracks or holes in foundation walls (not caulked)			

Weird Leaks
A chimney is a big hole in your building's envelope. A fireplace can be sealed with its damper or, even better, a tight-fitting cover of insulating board.

Kitchen and bathroom ventilators are helpful, especially if you have an air-conditioner. Otherwise the air-conditioner must use energy to remove extra moisture from the air. But when ventilators aren't being used, they need a cover. Do you have ventilators? YES NO

In some houses, the wind gets in through electric wall sockets and switches. Can you feel a draft near your outlets? Inexpensive foam inserts can seal these leaks. (Turn off the power first!)

If you have a clothes dryer with an outside vent, you should keep the dryer door closed when you're not using the dryer in winter.

Doors are big holes—especially when they're open. Breezeways and vestibules are like an airlock on a spaceship. They keep the wind from blowing straight through the house.

Some kids (and adults) just can't seem to learn to shut the door. Is this a problem in your house? YES NO
If it is, door closers can be installed. They never forget.

Indoor Air Pollution
In every house people do things that pollute the air. They smoke tobacco, and burn natural gas or kerosene. They fry food. They glue things together. They use cleaners and polishes that evaporate, and hair sprays and paint. Plastics, particle board, and even soil and stone may give off harmful gases. Is air pollution created inside your home? YES NO

In a leaky house, these pollutants are flushed out by all the outside air moving through the house. As we seal the leaks, pollutants can build up. To get rid of the pollutants, a tightly sealed house uses an appliance called an air-to-air heat exchanger. The heat exchanger pushes air out of the house, but saves heat by transferring it from the heated stale air to the fresh air it is pulling into the house.

Insulation: Stop Thief!

Some materials conduct heat better than others. Metal is used in cooking-pots because it is a good conductor of heat. In a house, we want to keep heat from escaping. We don't want walls to conduct heat. So we need building materials that are poor conductors of heat. Such materials are called **insulation.**

R-value is a number used to describe how good an insulator a material is. The higher the R-value, the greater the **R**esistance to the flow of heat. Here are the R-values of a *one-inch thickness* of some materials:

Put a checkmark by useful insulators.

		good insulator?
aluminum	R-0.0007	
wood, plywood (Douglas fir)	R-1.25	
common brick	R-0.20	
plasterboard	R-0.90	
snow	R-0.25	
cast iron	R-0.002	
concrete	R-0.08	
glass fiber board	R-4.00	
stucco	R-0.20	
window glass	R-0.14	
polyurethane foam	R-6.25	
cellulose	R-3.5	
fiberglass batts	R-3.1	

How Much and Where?

Buying insulation costs money. Installing insulation costs money. How much insulation should we buy, and where should we put it, so that we spend as little as possible on energy and insulation combined?

The part of a house to insulate first is the attic, because that is where the most heat is lost. Hot air rises, and the ceiling of a room will be warmer than the floor.

On page 37, you figured out the number of heating points plus attic cooling points for your climate and cost of energy. Use the table (right) to find the R-value of the insulation recommended for your attic or ceiling.

The thickness of the insulation doesn't matter, as far as saving heat goes. All that matters is the R-value of the total thickness.

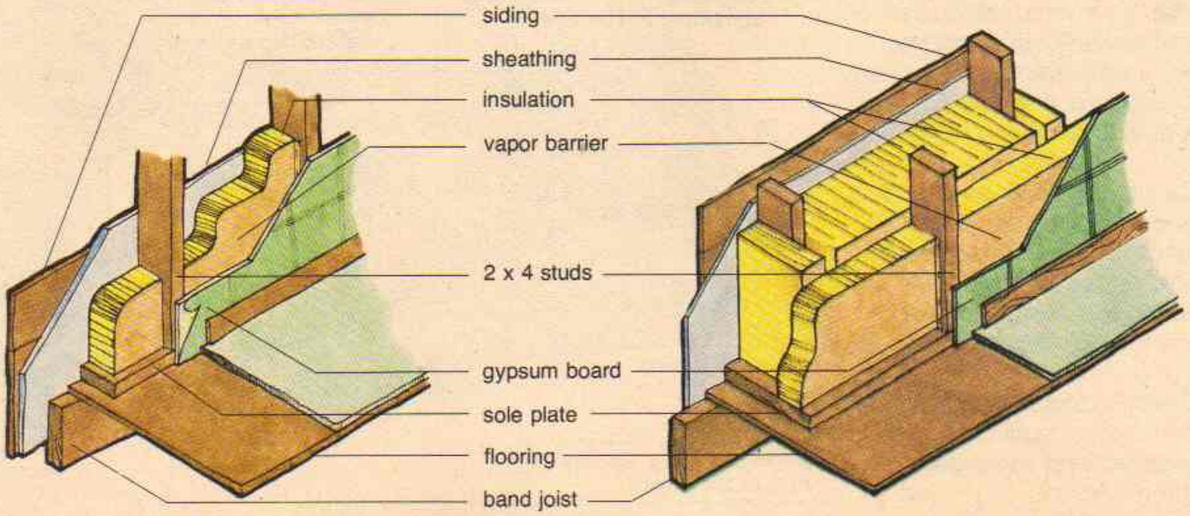
Heating Points plus attic cooling points	R-Value
1-3	R-0*
4-9	R-11
10-15	R-19
16-27	R-30
28-35	R-33
36-45	R-38
46-60	R-44
61-85	R-49
86-105	R-57
106-130	R-60
131 up	R-66

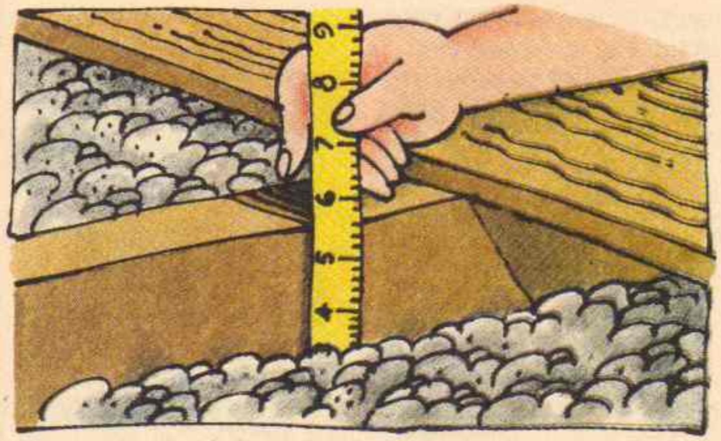
*However, many building codes require more insulation than this.

Heating points plus cooling points for walls	Existing wall	New wall	Smallest window size on which storm windows will be economical
0-3	none	none	none
4-10	none	R-11	none
11-12	R-14*	R-11	20 square feet
13-15	R-14*	R-11	15 square feet
16-19	R-14*	R-13	12 square feet
20-28	R-14*	R-13	9 square feet
29-35	R-14*	R-13	6 square feet
36-45	R-14*	R-19	4 square feet
46-85	R-14*	R-19	All windows
86 up	R-14*	R-23	All windows

*The walls in most houses are made with two-by-fours. There is less than four inches of space in the wall in which to put insulation. Blowing conventional insulation into this space in an existing wall can provide R-14, no more, no less.

To get higher values, people have invented new ways of building walls.





Inspecting the Attic or Ceiling

If you can, get an adult to help you inspect the attic of your home. (DO NOT do this alone.) Be careful not to step on the ceiling board—you could go through the ceiling of the room below! Don't touch the insulation; if it's fiberglass, it could irritate your skin.

Measure the thickness of the insulation. What kind of insulation is it?

____________________ inches.

Kind: ____________________

The attic is the first place to insulate. If you discover that it is not insulated, the chances are the walls aren't either.

Inspecting the Walls

On a cold day, feel a wall that faces the outside of your home, and a wall in the same room that separates two rooms. Is the exterior wall much colder? The bigger the difference, the less insulation there is in the wall. (Are the exterior walls much colder at the top than the bottom? If they are, they may contain insulation that has settled to the bottom.)

Every way of checking wall insulation needs an adult's help, because you have to find or make a hole in the wall. Electric outlets can be ready-made holes. Have an adult turn off the electric power at the central box, remove the cover plate, and look around the metal box. You may be able to see insulation. This method is not foolproof, though, because the installers may have deliberately kept the insulation away from the electric boxes. Another existing hole that can be checked is the place where the TV antenna lead comes in. Professional home energy auditors will sometimes drill a hole in the wall.

Inspecting the Insulation Under the Floor

With the help of an adult, check your crawl space or basement. Is there insulation between the floor joists?
YES NO
Along the band joist?
YES NO
Are the walls of the basement insulated?
YES NO

Inspecting the Doors

Here are some typical R-values for doors:

Wood door, 1½" thick	R-2
Wood door, 1½", with wood storm door, 50% glass	R-3.7
Metal door, urethane foam core	R-5.3

In your home, which do you think is more resistant to the passage of heat, the WALLS or the DOORS? (Circle one.)

If you had between 16 and 65 heating points on page 37, it might pay you to use storm doors; if it was over 66, you definitely need storm doors.

Do you have a door to an attic, or to any other unheated space, like a garage? These can often be insulated very easily.

Inspecting the Windows

Here are some typical R-values for windows:

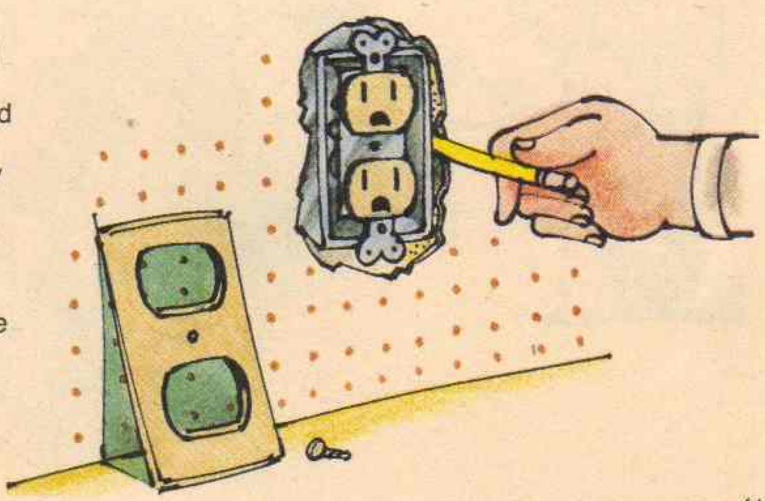
Single	R-1
Single with storm window or double-glazing	R-2
Double with storm window or triple-glazing	R-3

In your home, which do you think are more resistant to the passage of heat, the WALLS or the WINDOWS? (Circle one.)

Do you put up storm windows every winter?
YES NO

Check the table to see if storm windows are recommended for your number of wall points.

There are many other ways of improving a window's resistance to heat flow, including insulated window shades, shutters, and other coverings.



When you're hot, you're hot;

Here are some of the energy sources people use to heat their homes. Circle the energy source or sources you use to heat your home.

Natural gas

Fuel oil

Electric resistance

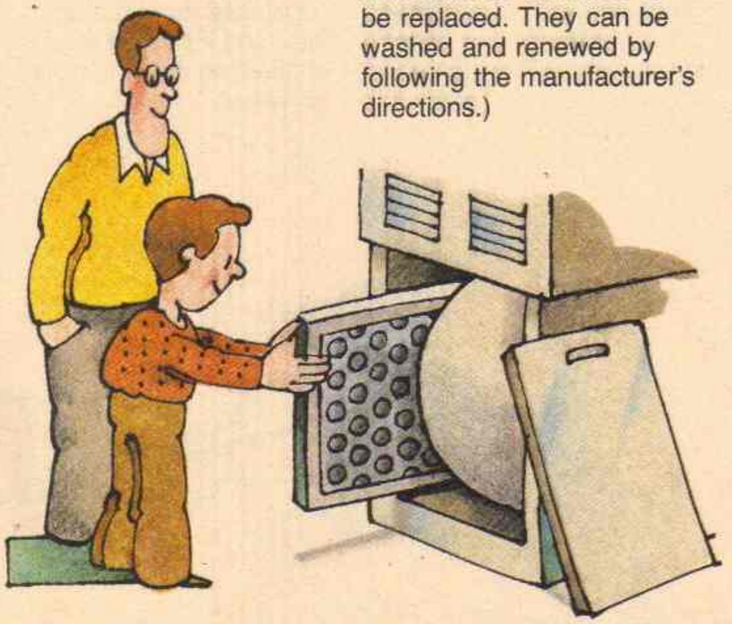
Electric heat pump

Sunlight

Wood

Coal

Geothermal



If you tried to reduce the amount of energy used to heat your home, how could you tell whether you had succeeded?

____

____

Furnace Inspection

If you live in a large apartment building, ask the superintendent to show you and the other students the furnace and water heater.

1) With the help of an adult, find the filter in your furnace. Slide the filter out of the furnace. Hold it up to the light. If you cannot see light through it, the filter is clogged and should be replaced. Hardware stores sell filters for a few dollars; be sure to take the measurements with you. Bring the used filter to school. (A few furnace models have permanent filters that do not need to be replaced. They can be washed and renewed by following the manufacturer's directions.)

2) When was the last time this furnace was checked? (A tune-up can lower fuel costs as much as 10%.)

____

3) Is there anything near the furnace that could catch fire easily (like paint or rags)?
YES NO

4) Do the ducts carrying heated air, or the pipes carrying steam, go through unheated spaces?
YES NO
Are they insulated?
YES NO

5) Find the thermostat for your furnace. What temperature do you usually keep it set at during the winter?

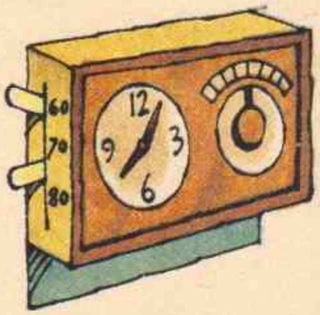
____

Do you turn it down at night? YES NO
To what setting?

________________________ °F

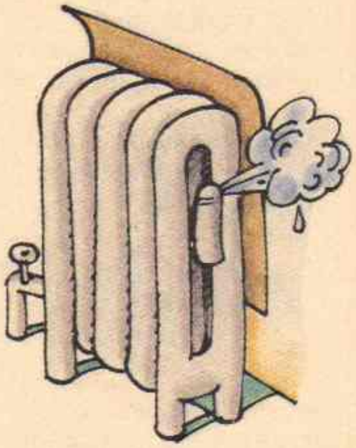
Make a rough estimate of how much money you could save by choosing a lower thermostat setting. In a 4000-5000 heating degree day climate, lowering the thermostat setting 3°F will save 10% of your heating bill. In colder climates, the percentage of savings will be less; in warmer climates, more. The savings in dollars are greatest in cold climates because people there spend much more for heat.

Lowering the thermostat setting 10°F for 8 hours each night can save from 10% to 16% of the heating bill. Clock thermostats can do this automatically.



On the coldest days in winter, the furnace should run almost continuously. If it doesn't, the burner is probably the wrong size.

Do all the rooms in your home need to be heated to the same temperature? How can your heating system be adjusted to keep some parts of your home warmer than others?



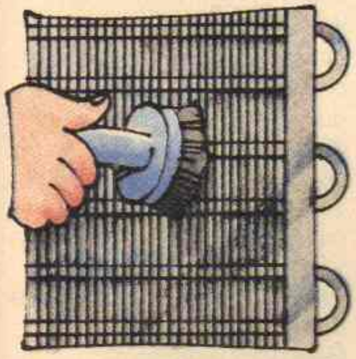
If you have steam heat with radiators, try putting reflectors behind radiators (you can make them out of heavy-duty aluminum foil). If you don't have automatic valves that bleed air from your radiators, who in your family knows how to do this?

when you're not...

Inspecting the Air Conditioner

With the help of an adult, find your air conditioner and answer these questions:

1) A dirty filter in an air conditioner creates the same problems as a dirty filter in a furnace. Where is the filter on your air conditioner? How do you clean it?



2) An air conditioner has coils just like a refrigerator. If the coils get dirty, they can't get rid of heat very efficiently. How do you clean them?

3) Does the noon sun ever shine directly on the air conditioner? That heats it. Is there any way to shade it?

4) What is the thermostat setting? Raising the temperature setting by 6°F (for example, from 67°F to 73°F) during warm weather might save 12% to 47% of the cooling costs.

Windows Can Help to Heat Your Home

Did you ever get into a car that's been sitting in the sun with the windows rolled up? Hot, wasn't it? Houses are like that, too. Every building with windows that let in direct sunlight is a solar collector. When we want heat, we should let sunlight in. When the weather is too hot, we want to keep direct sunlight out.

In the United States, the sun is always in the southern half of the sky, so windows which face north never let in direct sunlight. In cold weather, north-facing windows are heat-losers. (Remember, windows have a lower R-value than walls.) Windows facing south *can* let in direct sunlight and can help to heat your home, especially if you cover them with insulation at night.

A Window Audit

Which way is north where you live? A street map shows this. Then count your windows. If your windows are different sizes, count the larger windows as as many smaller windows as it would take to make one big one.

Good for light but not heat: north, northeast, northwest, or always in shade:

_______________ windows

Some help: east or west:

_______________ windows

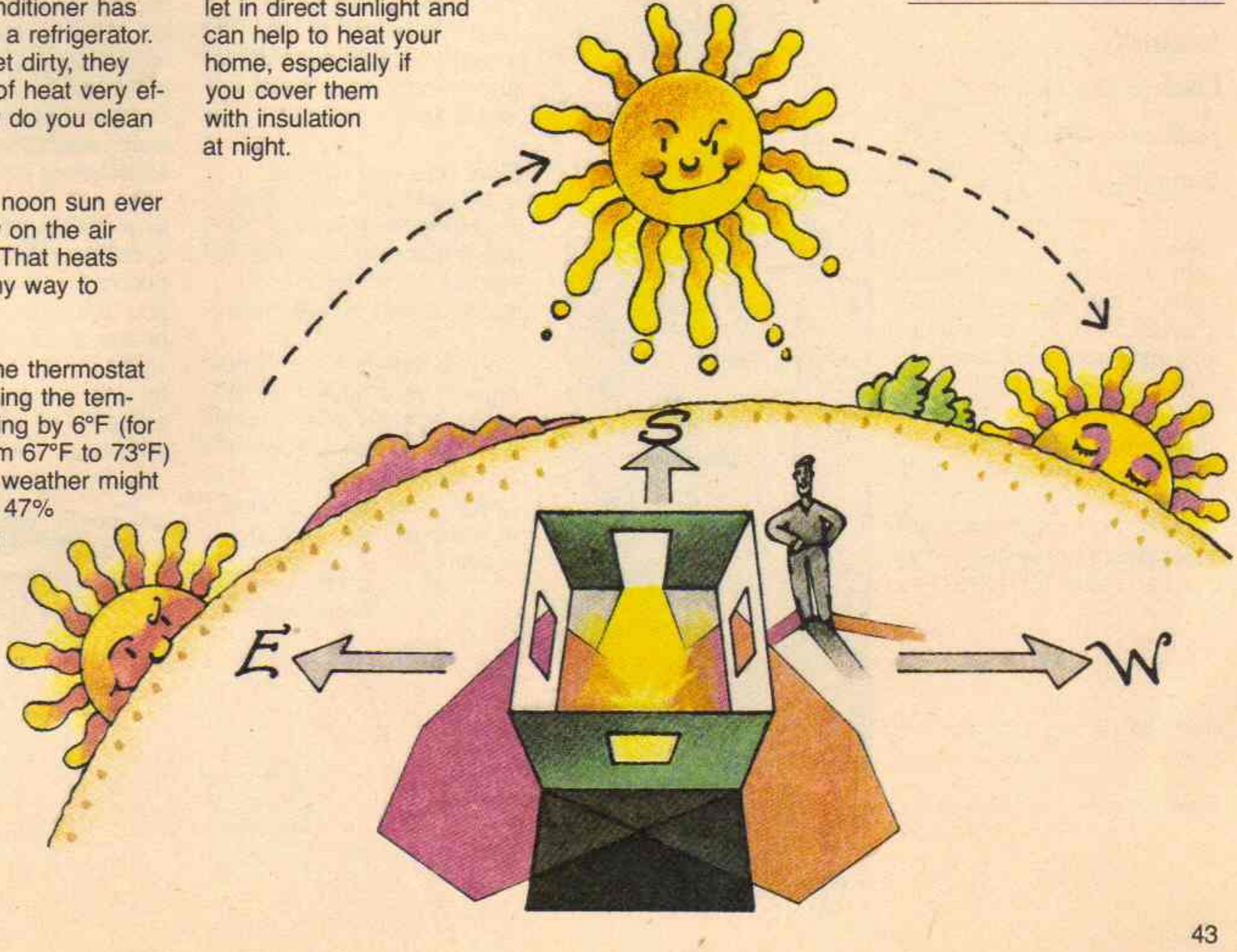
Might be a good source of heat: south, southeast, or southwest:

_______________ windows

Do you think the windows in your home have been well-planned to take advantage of heat from sunlight?

When the weather is too warm, you will want to shade any windows that could let in direct sunlight. What kind of shade do your south-facing windows have? What kinds could they have?

	do have?	could have?
awnings		
a building overhang		
trees that shed their leaves in winter		
vines on a trellis		
any other?		



Getting Into Hot Water

Turn to page 29. Look at the part of the graph marked "Residential." The orange part of the bar represents all the energy used to heat water in American homes. Of all the uses shown under "Residential," where does water heating rank? (Circle one.)

First

Second

Third

Fourth

Tenth

What energy source does the water heater in your home use?

Gas

Electricity

Electric heat pump

Fuel oil

Sunlight

Inspecting Your Water Heater

1) Get an adult to help you. Find your water heater.

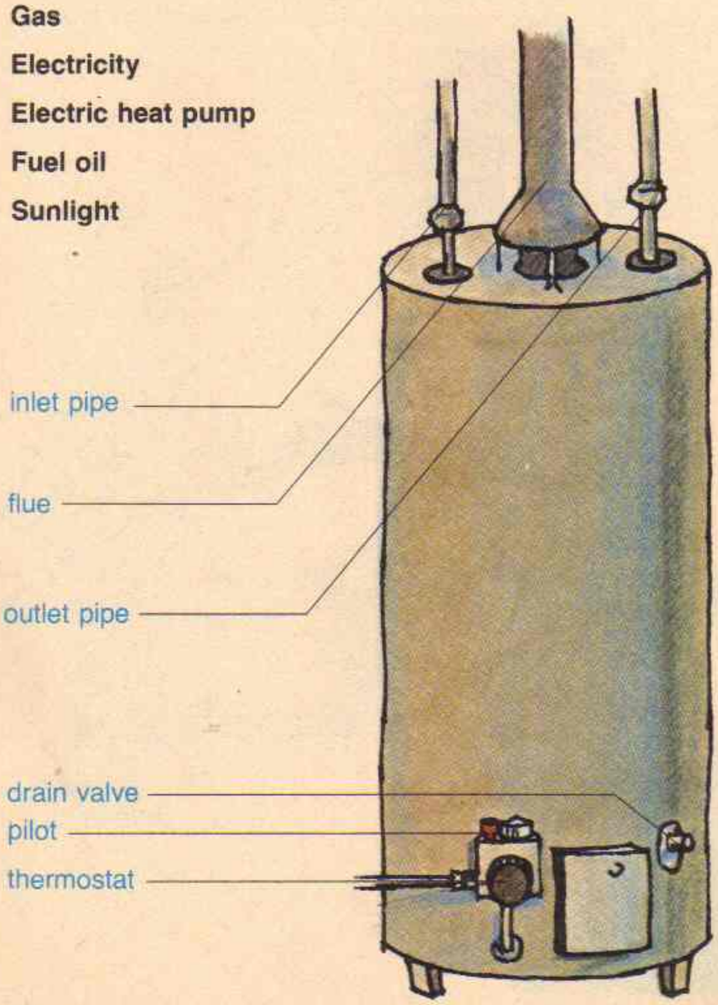
Have people left anything around the heater that could catch fire and burn? YES NO

What is the thermostat setting?

°F

Who in your family knows how to adjust the thermostat and relight the pilot?

If it is an oil or gas water heater, identify the parts.



2) Trace the hot water pipes. Do they go through an unheated area?

YES NO

Are they insulated?

YES NO

If you have a gas or fuel oil water heater, wait at least one hour after someone has used the hot water. Ask an adult to help you open the drain valve and drain off a couple of bucketfuls of hot water. Be careful not to scald yourself. Let the sediment settle and bring some to school in a jar to show the class.

You can save money by turning down the thermostat on your water heater. (But, if you have an older dishwasher that does not have its own water heater, it needs 140°F water. In that case, you should not use a lower water heater setting.)

Older gas- and oil-fired water heaters need more insulation. A fiberglass jacket that wraps around the heater can save as much as 15% on fuel costs.

Do you have a faucet that drips in your house? How many minutes does it take to fill a measuring cup? Sixteen cups make a gallon. How many gallons of water will you lose in a year?

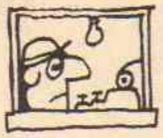
Wash your hands. Did you turn on the hot water? Did the water get hot before you finished? If it didn't, it's sitting in the pipe cooling off. You might as well not have used hot water at all. Try the experiment with different people. Give the pipe at least one-half hour to cool off between trials.

Any way of reducing hot water consumption will lower your energy bill. For example, there are shower heads that use less water but rinse you just as well. Or, for a few cents, you can put in a flow restrictor in the shower head you now have.

What kinds of laundry need to be done in hot water? Read the directions on detergent boxes. Read the laundry instruction tags on clothing. What could you wash in cold water? Try it and see if a cool water wash does a satisfactory job.

In some places, electricity is cheaper at night than during the day. If it is and you use an electric water heater, it can pay to heat water at night and store it for use in the day. Is there a special nighttime price where you live?

Reviewing Conservation



You have learned a great deal about home energy conservation. Show how much you know by circling T (for True) or F (for False) after the questions. A few questions must be answered by writing the answers on the line provided.

True or False?

An R-66 wall is a good investment for someone building a new house, no matter where she lives.

T F

Cold winter air can enter a home through the electrical outlets.

T F

During the hottest months, a person with air conditioning can save money by lowering the thermostat setting.

T F

A great deal of heat escapes from the average home through the windows.

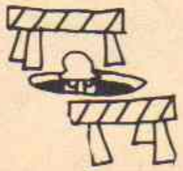
T F

How much energy a cook consumes depends entirely on which recipes are cooked and the types of pots and stove used.

T F

Aluminum siding is an excellent insulator.

T F



In winter, warm air can escape from the home through an open dryer door.

T F

Space heating and water heating are the two biggest uses of energy in the home.

T F

Questions

You want to insulate your attic. The lumber yard clerk shows you two kinds of insulation batts. One is 6 inches thick and has an R-value of 20. The other is 4 inches thick and has an R-value of 20. Which will keep your home warmer, the 6-INCH or the 4-INCH?

On day A the highest outside temperature was 90°F and the lowest, 30°F; on day B, 70° and 40°. On which day would you expect a house to have used more energy for heating?

A B

What is the name of the material used to fill the hole between a window frame and the siding of a house?

____

What is the name of the material put between a door and door frame to block air leaks?

____

____

How can you tell if a furnace filter is clogged?________

____

____

Refrigerators

Think of your refrigerator as a small, well-insulated, air-conditioned house. To keep it working efficiently, you can apply the same principles used in your home.

Around the door of the refrigerator is a piece of weather stripping. (On a refrigerator it's called a door gasket seal.) Find it on your refrigerator. This piece of rubber keeps cold air in and warm air out. But it wears out. To test it, close the door on a clean dollar bill. Pull the bill out. If you don't feel any resistance, the door gasket needs to be replaced.

Is this a problem with INFILTRATION or with INSULATION? (Circle one.)

Somewhere on every refrigerator, on the back or underneath, are the coils. Find them on your refrigerator. Feel them. The coils are warm because through them the refrigerator gets rid of heat it has taken from the inside of the refrigerator. Sometimes the coils get dusty. Dust keeps the heat from escaping. Clean the coils by vacuuming them or brushing with a clean, soft brush. Careful, they're very delicate.

Have you fixed a problem with INFILTRATION or with INSULATION? (Circle one.)

Conservation: Energy & happiness

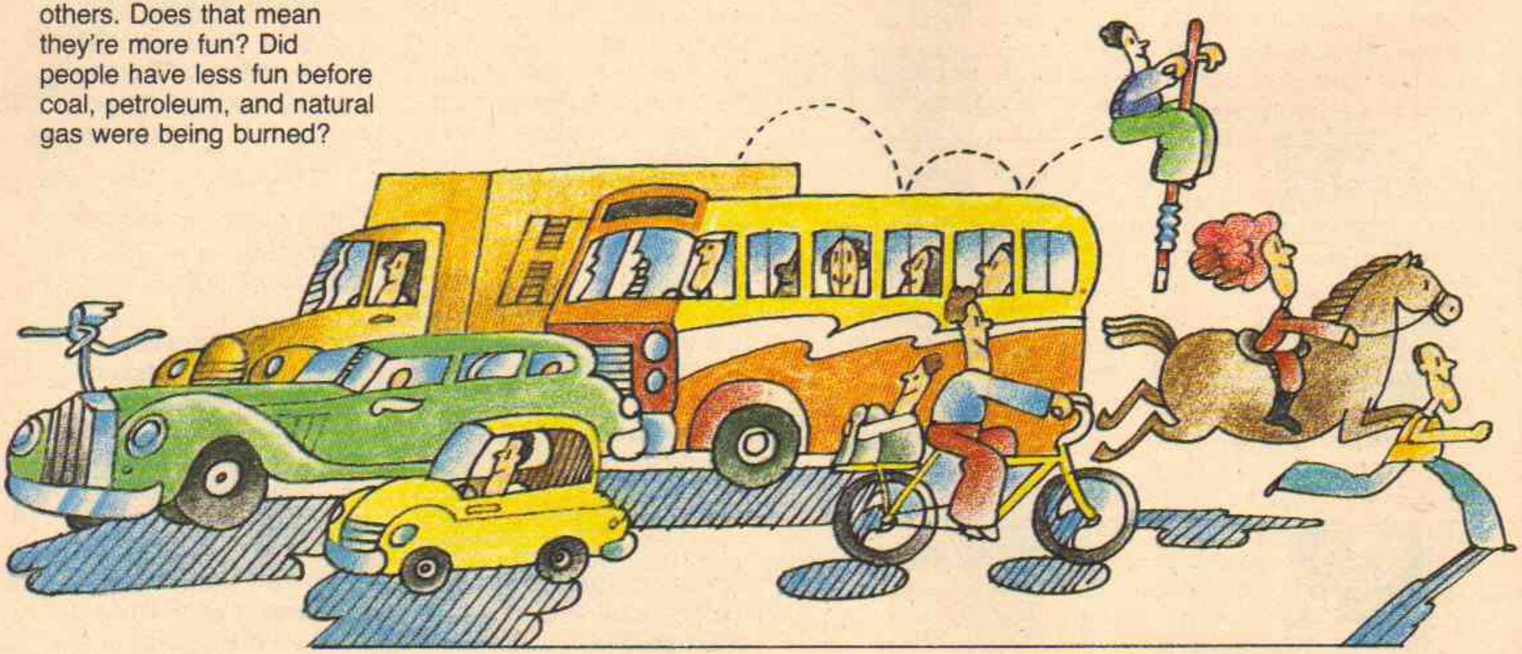
Some people seem to believe that to have a better life, you have to use more energy. You need a bigger car, more meat on the table, air conditioning, power roller skates, a motor boat, and so forth. Then life would really be fun. Is this true? Or is it possible to use less energy and also enjoy life more?

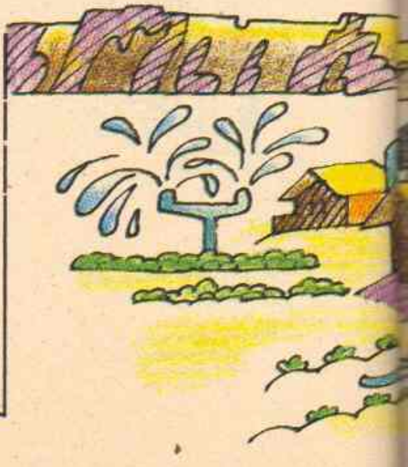
Some ways of having fun use more energy than others. Does that mean they're more fun? Did people have less fun before coal, petroleum, and natural gas were being burned?

A quarter of all the energy used in the United States is used directly for transportation. People needed to go from place to place. Different ways of going use different amounts of energy. In a city, it takes a bus about 3,800 Btu's of energy to carry a person one mile. It takes a car 8,100. Suppose the bus system does use less energy than the private car system. Will your life be less fun if you go by bus instead of by car?

A private car can be as clean and comfortable as we can afford. It saves our time by leaving when we are ready and going exactly where we want. It protects us from the weather and takes us long distances fairly quickly.

On the other hand, buying and using a car costs money that might have bought other satisfactions. Parking hassle is a cost, and there are costs paid by the community, like the cost of space for roads, parking lots, and service stations, and costs of air pollution damage. Everybody needs to think carefully about *all* the costs and benefits of the forms of transportation they choose. You might not choose to ride a bicycle just because it's energy-efficient, but you might if it also keeps you healthier.



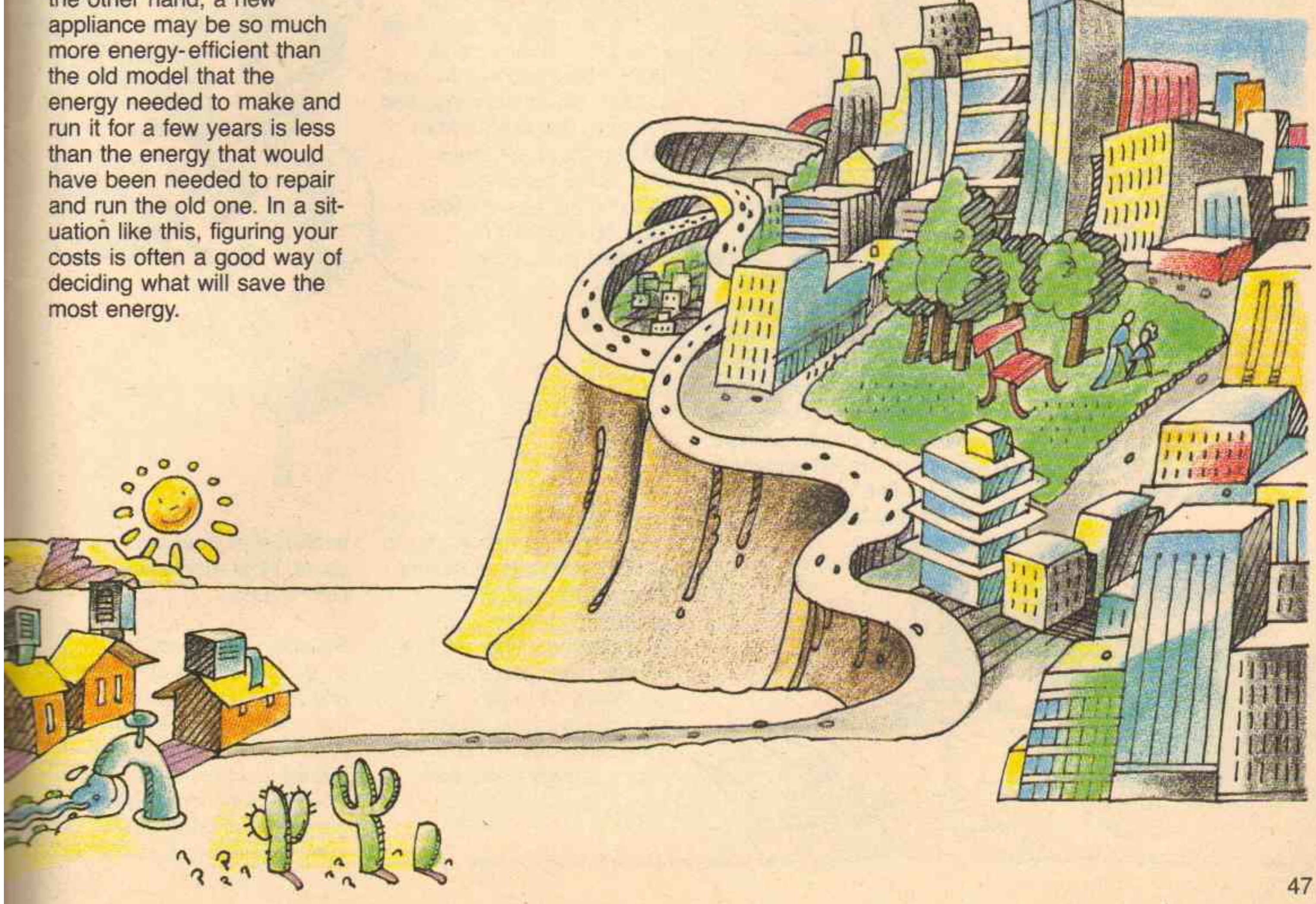


A lot of energy goes for making and moving things that soon end up as rubbish. Then we use more energy hauling the rubbish away. An appliance that can be easily repaired and lasts a long time saves the energy that would be needed to make and deliver a new one. On the other hand, a new appliance may be so much more energy-efficient than the old model that the energy needed to make and run it for a few years is less than the energy that would have been needed to repair and run the old one. In a situation like this, figuring your costs is often a good way of deciding what will save the most energy.

But not always. Take paper bags. Supermarkets give them away "free" by charging every shopper a little bit extra on everything they buy, to pay for the bags. In Europe, where bags aren't free, many shoppers bring their own and energy is saved.

In the past, we made certain choices partly because energy was cheaper than it is now, compared to other things. When gasoline was cheaper, many people who worked downtown decided to commute from the suburbs. It takes more energy per person to support a suburb dweller than a person living in a city apartment. Now young couples are moving back into some cities. They've found that for the same money they can have a better life living downtown.

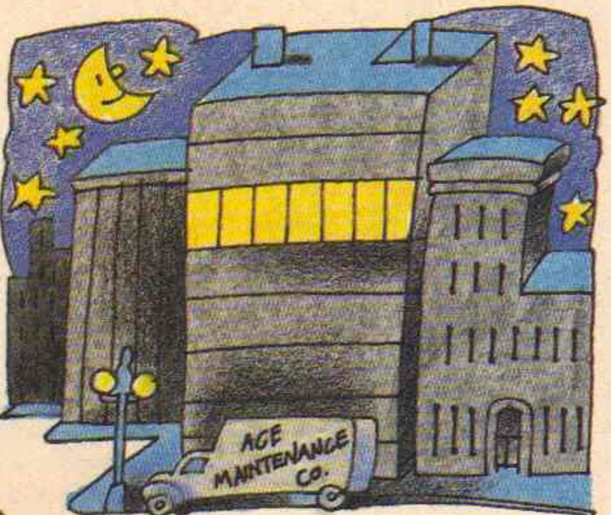
People who move from the wet Eastern parts of our country to the dry Southwest sometimes want to live in Cape Cod houses with green lawns. But it takes extra energy to do that. Their grown-up children may rediscover the energy-saving architectural principles Indians and early Spanish settlers worked out. Do you think people who adapt their lifestyle to their climate are any less happy than those who don't?



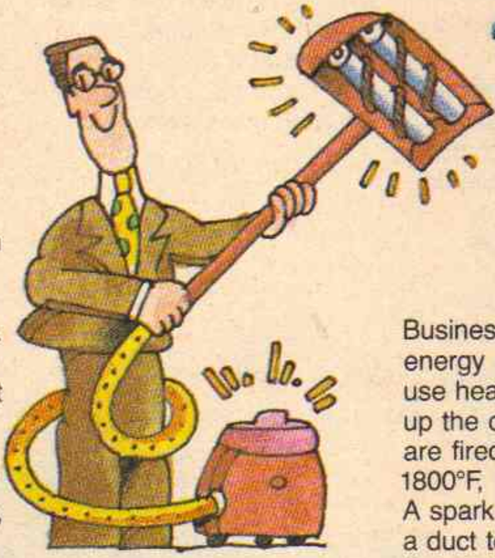
Energy saving at work

Businesses and industries need energy to provide the goods and services we buy. Rising energy costs are making business people look for ways they can produce more using less energy. Since the 1973 Oil Embargo, business in general seems to have done a better job of saving energy than households have done.

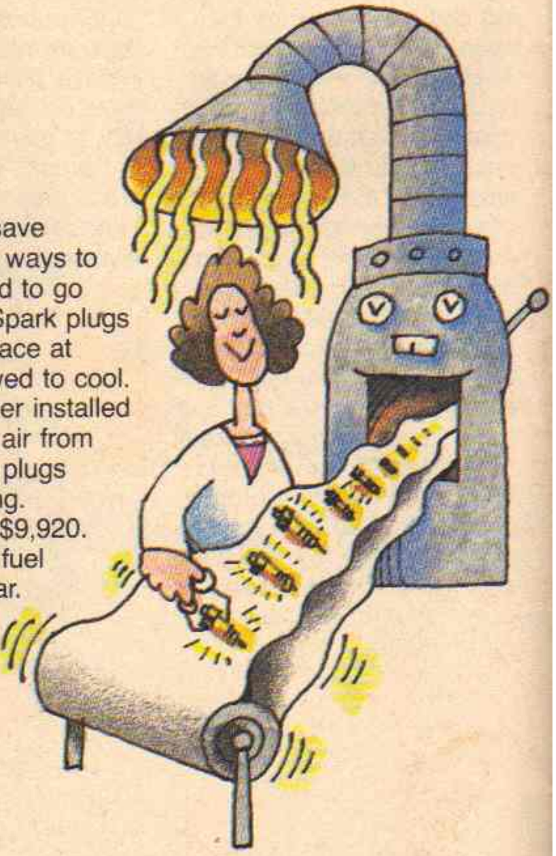
One way businesses save energy is by practicing thrifty habits. One office building asked all night cleaning crews to work on the same floor at the same time, leaving other floors dark. Hundreds of dollars worth of electricity were saved each month.


ACE MAINTENANCE CO.

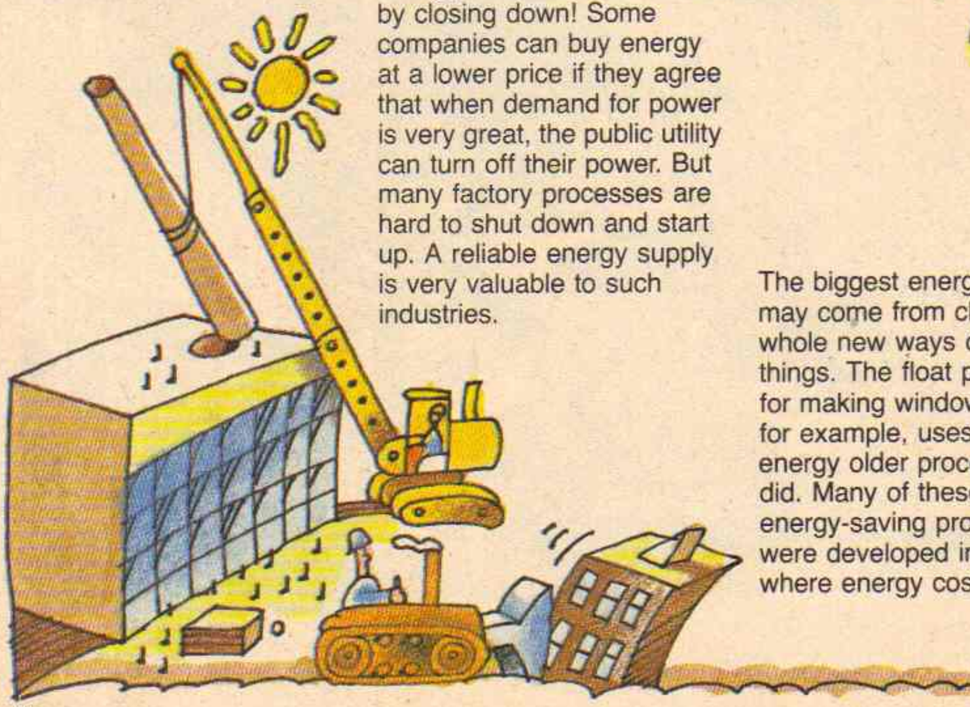
Industries can seek substitutes for energy. Sometimes more labor can be used instead of energy. Using new materials can save energy. A vacuum cleaner maker changed from die-cast metal to plastic. It took oil, gas, and energy to make the plastic and mold it. (The color and all the screw holes were molded in.) But it took almost three times as much energy to smelt the metal, cast it, drill the screw holes, buff it, make the paint, and paint it.



Businesses also save energy by finding ways to use heat that used to go up the chimney. Spark plugs are fired in a furnace at 1800°F, then allowed to cool. A spark plug maker installed a duct to use hot air from the cooling spark plugs to heat the building. The change cost $9,920. $25,546 worth of fuel is saved each year.



Energy costs can be reduced by closing down! Some companies can buy energy at a lower price if they agree that when demand for power is very great, the public utility can turn off their power. But many factory processes are hard to shut down and start up. A reliable energy supply is very valuable to such industries.



The biggest energy savings may come from changing to whole new ways of making things. The float process for making window glass, for example, uses half the energy older processes did. Many of these energy-saving processes were developed in countries where energy costs have been higher than ours for years. Now America is catching up.

Building whole new factories takes a lot of money and effort. But improving the energy-efficiency of American businesses will reduce costs and our need to import oil, and provide jobs in healthy, competitive industries.

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